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Agro-economic policy analysis with the regional production model ACRE – A case study for Baden-Wuerttemberg

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List of abbreviations and units

% UAA	percent of utilized agricultural area
ACRE	Agro-eConomic pRoduction model at rEgional level
AEM	agri environmental measure
AEP	agri environmental program
AL counties	farm type: arable land counties
AL	arable land
AL-CC	farm type: cash crop counties
AL-FC	farm type: fodder crop counties
APM	agricultural policy model
BMELV	Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (egnl. Federal Ministry of Food, Agriculture and Consumer Protection)
BW	Baden-Wuerttemberg, i.e. the model region
CAP after 2013	European common agricultural policy in the period between 2014 to 2020, newly also referred to as "CAP towards 2020"
CAP	European common agricultural policy
CAP2003	scenario simulating the agricultural policy reform CAP 2003 in the year 2015, i.e the baseline scenario
CH_4	methane (greenhouse gas)
CO_2	carbon dioxide (greenhouse gas)
csv	comma separated values
EAE	Estimation of the agregation error
EEC	European Economic Community
EmaizeSM	energy crop scenario simulating energy maize production activity with low competetiveness between energy maize and food production, calibration parameters derived from activity of silage maize production
EmaizeWW	energy crop scenario simulating energy maize production activity with high competetiveness between energy maize and food production, calibration parameters derived from activity of winter wheat production
EU	European Union
EUR ha^{-1}	euro per hectare

EXT	combined scenario simulating extensive agricultural production
GAMS	General Algebraic Modeling System
GHG	greenhouse gas
GL counties	farm type: grassland counties
GL	grassland
GL-EG	farm type: extensive GL counties
GL-FC	farm type: grassland fodder crop counties
GL-IG	farm type: intensive grassland counties
INT	combined scenario of intensive agricultural production
kg	kilogram
LP	Linear Programming
m	meter
MAD	mean absolute deviation
Mandatory AEM	scenario assuming mandatory agri environmental programs
MAPF	mean absolute percentage deviation
mm a^{-1}	milimeters per year
MS	member state
N	nitrogen
N_3H	ammonium (greenhouse gas)
NA-2	crop rotation with four crop groups
NB-1	cattle density is between 0.3 and 2.0 LU per hectares
NB-2	cattle density is between 0.3 and 1.4 LU per hectares
NC-4	regional typical pasture
NE-2	greening of arable area in autumn
NE-3	greening of set-aside area
NO_2	nitrogen dioxide (greenhouse gas)
NOx gases	nitrogen oxides (greenhouse gases)
Nred10%	nitrogen reduction scenario with reduction of nitrogen input by 10%
Nred170kg	nitrogen reduction scenario with a constraint of organic nitrogen input limiting the input of organic nitrogen to 170 kilogram per hectare utilized agricultural area

NUTS	Nomenclature of Territorial Units for Statistics, derived from the French term "Nomenclature d'unités territoriales statistiques", defined according to population
NUTS0	EU member state level
NUTS1	administrative unit which describes the federal state level, population 3 to 7 million
NUTS2	administrative unit which describes the district level, population: 0.8 to 3 million
NUTS3	administrative unit which describes the county level, population: 0.15 to 0.8 million
NUTS4	administrative unit which describes the municipality level, population: less than 0.15 million
PAD	percentage absolute deviation
PMP	Positive Mathematical Programming
pp UAA	percentage points of utilized agricultural area
pp	percentage points
RAUMIS	Regionalisiertes Agrar- und Umweltinformationssystem fuer die Bundesrepublik Deutschland (regional agricultural and environmental information system for Germany)
REF	reference year simulating Agenda2000 reform in the year 2000
SUBred60%	subsidy reduction scenario with a reduction of payments form Pillar 1 by 60 percent
SUBshift70%	subsidy reduction scenario with a shifting of payments from Pillar 1 to Pillar 2 by 70 percent
TGM	total gross margin
VG	Vergleichsgebiet
VGG	Vergleichsgebietsgruppe
WAD	weighted absolute deviation

List of abbreviations of NUTS3 counties in Baden-Wuerttemberg

AA	Ostalbkreis
BAD	Baden-Baden
BB	Boeblingen
BC	Biberach
BL	Zollernalbkreis
CW	Calw
EM	Emmendingen
ES	Esslingen
FDS	Freudenstadt
FN	Bodenseekreis
FR	Breisgau-Hochschwarzwald
FRsk	Freiburg i.Breisgau
GP	Goeppingen
HD	Rhein-Neckar-Kreis
HDH	Heidenheim
HDsk	Heidelberg
HN	Heilbronn, county
HNsk	Heilbronn, city
KA	Karlsruhe, county
KAsk	Karlsruhe, city
KN	Konstanz
KUEN	Hohenlohekreis
LB	Ludwigsburg
LOE	Loerrach
MAsk	Mannheim
MOS	Neckar-Odenwald-Kreis
OG	Ortenaukreis
PF	Enzkreis
PFsk	Pforzheim
RA	Rastatt

RT	Reutlingen
RV	Ravensburg
RW	Rottweil
S	Stuttgart
SHA	Schwaebisch Hall
SIG	Sigmaringen
TBB	Main-Tauber-Kreis
TUE	Tuebingen
TUT	Tuttlingen
UL	Alb-Donau-Kreis
ULsk	Ulm
VS	Schwarzwald-Baar-Kreis
WN	Rems-Murr-Kreis
WT	Waldshut

1 Introduction

1.1 Policy background

Agricultural production in Europe is considered to be multifunctional. It has an important role in the domestic supply of agricultural products and as the main land user in the European territory it has responsibilities in landscape management. Furthermore, the agricultural sector often contributes considerably to the viability of rural areas (EC 2009A). The Common Agricultural Policy (CAP) of the European Union (EU) aims to regulate the agricultural sector so that it fulfils these multiple functions with respect to economic, supply and environmental objectives. Since its implementation in 1957 within the Treaty of Rome the initial objectives of the CAP have remained unchanged. However, over the course of time the different objectives' weighting has varied and the CAP has undergone several reforms[1] in order to improve the efficiency of the applied policy instruments and to adapt them to changing economic conditions and societal expectations and demands. Therefore the CAP developed from a policy focusing mainly on producer price support to a policy that supports producers' income more directly while also targeting environmental and rural development (EC 2009B).

When the CAP first was implemented, policy measures were mainly focussed on production and price support. Since the 1990s major reform packages have significantly modified the CAP. With the MacSharry reform, adopted in 1992 and implemented in 1994, the focus of farm support started to shift from prices to direct payments. To compensate farmers for income losses due to the cut in support prices the MacSharry reform introduced direct payments. These compensation payments were linked to fixed areas, to yields or to the number of animals (EC 2009B). For environmental concerns, Member States (MS) paid allowances (since 1987) for farming in environmentally problematic regions by agri-envrionmental programs (AEP), which were co-financed by the European Economic Community (EEC) (Osterburg and Stratmann 2002: 261).

[1] For an overview of the reforms, objectives and instruments of the CAP see Appendix 1.

With the Agenda 2000, decided in 1999, the impact of market price instruments in the CAP was further reduced and direct payments were further decoupled from production (payments for different products were more equalized). Agenda 2000 re-conceptualised the CAP as being based on two 'pillars'. Pillar 1 comprises the Common Market Organisations (CMO) with market and price policy instruments as well as coupled subsidies and direct income support. The newly introduced Pillar 2 concerns rural development and it is based on multiannual programs implemented by Member States, including regionally applied policy measures that are financed partially by EU budget and by national budget.[2] Within Pillar 2 increased attention was given to environmental concerns and in particular the compulsory agri-environmental programs had an important role (Osterburg and Stratmann 2002: 263, EC 2009B).

In 2003 the midterm review (MTR) of Agenda 2000 resulted with the so-called Luxembourg Agreement (CAP 2003 reform)[3] in a further reform and more market orientation of the CAP. The CAP 2003 reform, which was decided for the period from 2005 to 2013, was based on three elements: decoupled direct payments, statutory management requirements linked to the decoupled direct payments (so called cross compliance) and strengthening of Pillar 2.

With the CAP 2003 reform the decoupled payments from Pillar 1 are not related to a specific type of production but instead are linked to entitlements based on historical subsidy receipts. They replaced the compensation payments of the MacSharry and Agenda 2000 reforms and are meant to ensure a basic income support while at the same time allowing the farmers flexibility to produce market oriented goods (EC 2009B).

Cross compliance (CCP) is the obligation to follow statutory management requirements (SMR) in order to receive the direct payments from Pillar 1. These SMR prescribe farming according to good agricultural practice (e.g. animal and plant health), the maintenance of agricultural areas in good agricultural and environmental condition (GAEC) and the retaining of permanent grassland. Thus, CCP shall ensure the retaining of agricultural area and a production according to environmental standards (EC 2009B).

Strengthening of Pillar 2 includes modulation and reorganization of Pillar 2. Modulation means the shifting of budget from Pillar 1 to Pillar 2. Reorganization implies differentiation between four axes of Pillar 2 which address the following areas: improvement in competitiveness of farming and forestry (Axis 1), development of environment and countryside (Axis 2),

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[2] Pillar 1 and Pillar 2 are also referred to as First (1st) Pillar and Second (2nd) Pillar of the CAP.

[3] Also referred to as Fischler reform.

improvement of quality of life and diversification of the rural economy (Axis 3) and a Leader element for the implementation of the other three axes (Axis 4) (EC 2009B).

1.2 Problem specification and objectives of the study

Recent discussions on how to design the policy of the CAP after 2013[4] consider the objectives of food security in the context of a rapidly increasing world population, sustainable land management, rural development, new environmental challenges, volatile markets, provision of public goods and other social demands for the agricultural sector (EC 2009A). Regional heterogeneities in agricultural production conditions and structures between and within Member States (MS) require a regionally adapted implementation of CAP instruments to address these objectives efficiently. One example of a region where agricultural production is of high importance and production structure is regionally quite heterogeneous is the German federal state Baden-Wuerttemberg (BW). Depending on the climatic and geographical conditions the agricultural production in BW varies from regions dominated by arable crop production to regions with high shares of permanent grassland. Regions with warmer climatic conditions and fertile soils are characterized by high shares of arable production and cattle and pig fattening as well as dairy production based on forage. Regions with colder climatic conditions and higher precipitation as well as less fertile soils are dominated by grassland farming with dairy production (Arndt 2005).

Due to the regional heterogeneity and the multifunctional character of agricultural production the impacts of policy changes are not easy to estimate. However, information regarding potential impacts is important for politicians and stakeholders, especially to support policy decisions at regional level. Agricultural policy models (APM) are tools to analyse the effects of agricultural policy intervention, i.e. they provide information about the possible impacts of changes in policy and therefore can provide support for decision making. In this study the agricultural policy model ACRE (Agro-eConomic pRoduction model at rEgional level) is applied to analyse the effects of different changes in agricultural policy at the regional level of Baden-Wuerttemberg.

Within this framework, the objective of this study is to analyse different agricultural policy scenarios for Baden-Wuerttemberg and at the same time improve and evaluate the suitability of

[4] CAP post 2013 is currently also referred to as "CAP towards 2020".

the regional supply model ACRE as a tool for policy analysis and support. In particular the study aims to address the following research questions:

What are the regional impacts of different policy measures in the German federal state Baden-Wuerttemberg with respect to economic, production and environmental objectives?

How suitable are the simulated policy measures for achieving the policy objectives of the CAP 2003 reform, as well as the objectives of subsidy reduction, promotion of energy crop production, reduction of environmental pollution and promotion of agro-environmental measures?

How suitable is the regional supply model ACRE as a tool for policy analysis and policy decision support?

1.3 Structure of the study

In order to address the research questions the study is structured in four chapters with the hierarchy of sections and subsections.[5] Chapter 2 comprises the theoretical and methodological framework of the study as well as a description of the study region. In Section 2.1 the theoretical framework for the policy analysis is delineated, followed by a detailed description of the study region Baden-Wuerttemberg in Section 2.2. A detailed introduction into the agricultural policy model ACRE is given in Section 2.3.

Chapter 3 describes and analyses the simulated policy scenarios according to scenario background, scenario assumptions, scenario modelling, analysis of results and scenario discussion. Section 3.1 is dedicated to the reference year which is the year 2000 and the baseline scenario, which represents a simulated projection of the future development of the agricultural sector in the study region under the policy of the CAP 2003 reform. Section 3.2 presents two scenarios in which the amount and instrument use of direct payments are modified in order to reduce the volume of subsidy. Section 3.3 deals with two scenarios in which the production of energy crops is considered under different market assumptions for energy crop demand. In Section 3.4 two scenarios addressing the reduction of nitrogen emissions production are presented. Section 3.5 presents one scenario in which agri-environmental measures are assumed to be mandatory. In Section 3.6 the assumptions of the scenarios from Sections 3.2 to 3.4 are combined to simulate two scenarios of different intensities of agricultural production. Chapter 4

[5] Maps, tables and figures without any given indication of the source are based on own presentations and/or base on own calculations.

concludes and discusses the study. Section 4.1 draws summarized conclusions from sections of Chapter 2 and Chapter 3, while Section 4.2 discusses the complete study with respect to its strengths and weaknesses.

2 Theoretical framework of policy analysis and description of the study region and of ACRE

The theoretical framework of this study follows an objective-instrument based agricultural policy analysis that comprises objectives, instruments and indicators and is described in Section 2.1. A detailed description of the study region Baden-Wuerttemberg is given in Section 2.2.

2.1 Agricultural policy analysis: objectives, instruments and indicators

Agricultural policy comprises all objectives and instruments which aim at creating a policy framework for agriculture and at influencing agricultural processes (Henrichsmeyer and Witzke 1994: 13). (Quantitative) agricultural policy analysis aims at studying the impact of agricultural policies on a range of indicators (e.g. income, production, amount of subsidies, environmental impact, etc.) at different levels of scale (e.g. global, national, sectoral, regional, or farm scale) (Happe et al. 2006: 48). The framework of the objective-instrument analysis (Ziel-Mittel Analyse) is used to analyse systematically the context between objectives and instruments with respect to the instrument specific effects on the objectives (and the optimal combination of instruments to achieve objectives) (Henrichsmeyer and Witzke 1994: 23, cf. Berg et al., 2003: 243).
In this study the theoretical framework of an objective-instrument based agricultural policy analysis is applied to the study region Baden-Wuerttemberg. The production decisions of the agricultural producers in the study region are influenced by policy instruments (e.g. subsidies, regulations) that aim at objectives of economic, social and environmental issues.

2.1.1 Policy objectives and relation of objectives

Agricultural policy objectives are the result of the political decision-making processes, thus they are regarded as politically determined (Henrichsmeyer and Witzke 1994: 22). In this study the policy objectives are given by the CAP (cf. Section 1.1, EC 2009B) and are formulated as three main and several sub-objectives which are interrelated competitively (negatively), complementary (positively) or neutrally (cf. Streit 2005: 278). For the purpose of this study the three main policy objectives analysed are subsumed as economic objectives, supply objectives and environmental objectives. Economic objectives include the reduction of public expenditures for subsidies (e.g. via the reduction of direct payments) as well as the stability of agricultural income. Supply objectives consider the supply of food from crop and animal production as well as energy supply from energy crop production. Utilized agricultural area (UAA) is an essential input factor for agricultural production. Thus, keeping UAA in good agricultural and environmental condition is also defined as a supply objective. The environmental objectives imply the reduction of production intensity and environmental pollution as well as the extension of areas under agri-environmental measures. In the following, the three main policy objectives and their related sub-objectives are described in more detail, followed by a description of the relation between the objectives.

Economic objectives

The economic objectives as analysed in this study refer to the sub-objectives of reducing subsidies on the one hand, while on the other hand agricultural income is aimed to be stabilised or even increased (EC 2009B).

Reduction of subsidies

Agricultural subsidies (payments from Pillar 1 and 2) are funded from limited budgets and are public expenditures covered by EU and MS taxpayers (cf. EC 2009B). According to the goals of the Lisbon Strategy (job creation, structural reforms, and social cohesion) public expenditures should be reduced and spend "to set the right priorities towards economic reforms, innovation, competitiveness and strengthening of private investment and consumption in phases of weak economic growth” (Treaty of Lisbon, 2008: 440). In line with the Treaty of Lisbon, one of the topics of former policy reforms as well as for the future CAP after 2013 is the efficient adjustment of subsidies that at the same time allows to retain a basic income support, the supply of agricultural commodities and the provision of public goods (EC 2009B).

Stability of agricultural income

According to the Treaty of Lisbon, a basic income support has to be provided to farmers in order to ensure a fair standard of living (Treaty of Lisbon, 2008: 81, Article 39 b). The stability of agricultural income[6] will also continue to be an objective of the CAP after 2013 (EC 2009B).

Supply objectives

The current objectives of agricultural policy still imply the increase of agricultural productivity and ensuring supplies to costumers (Treaty of Lisbon 2008: 81, Article 39 a, d, e). In this study the supply objectives are differentiated into the sub-objectives food supply, energy crop supply and retaining utilized agricultural area (UAA) as production factor.

Food supply

Food supply from agricultural production considers food from crop and animal production, which implies also production of fodder crops. While it is expected that agricultural production in the EU would not be stopped without income support to farmers, it is assumed to be more concentrated in the most competitive areas and result in negative economic, social and environmental consequences (cf. Section 1.2, EC 2009B).

Energy crop production

The objective of promoting renewable energy is stated in the Treaty of Lisbon (2008: 176, Article 194, b, c). The production of energy crops aims at three expected results: (1) to ensure energy supply;(2) to reduce greenhouse gas emissions and (3) to offer new job alternatives for farmers and strengthening agricultural production, forestry and rural areas (EC 2006A, BMVEL 2008A, MRL 2006A).

Retaining of UAA (landscape management)

Utilized agricultural area (UAA) is an input factor for agricultural production and should be kept productive according to the Treaty of Lisbon (2008, Article 39, d) to assure the availability of supplies. Furthermore, retaining of UAA prevents agricultural landscape as a public good from natural succession, an aspect that is particularly of a high relevance in the study region Baden-Wuerttemberg (cf. LUBW 2008: 5).

Environmental objectives

The CAP has subsequently been reformed in order to promote sustainable production and to ensure a healthy environment as well as a careful use of natural resources. These

[6] In this study the terms 'stability of agricultural income' and 'income stability' refer to keeping or increasing the income level of farmers "[…] by increasing the individual earnings of persons engaged in agriculture" (Treaty of Lisbon, 2008: 81, Article 39 b). The term 'stability' does not refer to reduction of volatility of income.

environmental objectives will be further requested in the CAP after 2013 (IOFAM 2009: 4, EC 2009B). In this study the environmental objectives include the sub-objectives reduction of production intensity, reduction of environmental pollution and increasing participation in agri-environmental programs.

Reduction of production intensity

Changes in agricultural subsidies might result in a concentration of agricultural production in most competitive areas and increased intensification, enhancing pressures on natural resources with negative environmental consequences. Therefore one policy objective is to avoid and to limit the regional concentration of intensive production and to promote extensive agricultural production (EC 2009B).

Reduction of environmental pollution

Agricultural production adds to environmental pollution due to the use of input factors (e.g. nitrogen) or negative external effects (e.g. soil erosion, greenhouse gas emissions). Nitrogen emissions by fertilisation and phosphate emissions by soil erosion result in pollution of ground and surface water. Organic and mineral fertilization as well as the digestion of ruminants produce greenhouse gases, which contribute to the global warming effect and to climate change. The Luxembourg Agreement and the CAP Health Check in 2008 already introduced more regulations addressing concerns of water pollution and climate change and the objective of reducing agricultural pollution will be further followed on the way to a CAP after 2013 (cf. EC 2009C).

Increasing area under agro-environmental measures

Farm management according to the rules of good agricultural practise is a precondition to ensure a sustainable and environmental friendly agricultural production. Application of agri-environmental measures (AEM) goes beyond the requirements of good agricultural practice (cf. Section 1.2). AEM are designed to encourage farmers to protect and enhance the environmental conditions on their farmland. Furthermore, AEM aim at reducing environmental risks and preserving nature and cultivated landscapes. Thus, an increase of area under AEM supports the objective to increase environmental friendly production and landscape management (EC 2005A: 3, 4).

Relation of the objectives

Basically policy objectives can be related in a complementary (positive), competitive (negative) or neutral way (Henrichsmeyer and Witzke 1994: 32). Complementary (positively) related objectives promote each other, i.e. aiming at objective A promotes automatically aiming at objective B (and possibly vice versa). Competitive (negatively) related objectives hinder or exclude each other, i.e. aiming at objective A reduces the effect of aiming at objective B (and possibly vice versa). Neutrally related objectives do not influence each other, i.e. aiming at objective A has no impact on aiming at objective B (and possibly vice versa). Table 2.1-1 presents the relations of the policy objectives examined in this study. The relations present the author's assumptions of reality and the expected outcome of the policy analysis and thus serve as working hypotheses.

Table 2.1-1: Relations of investigated objectives.

	Economic objectives		Supply objectives			Environmental objectives		
	Subsidy reduction	Income stability	Food security	Energy crop production	Retaining of UAA	Reduction of production intensity	Reduction of environ-mental pollution	Agri-environ-mental programs
Subsidy reduction		-	-	-	-	- / +	- / +	+ / -
Income stability			+	+	+	- / +	- / +	- / +
Food security				-	+	-	-	-
Energy crop production					+	-	-	-
Retaining of UAA						- / +	- / +	- / +
Reduction of production intensity							+	+
Reduction of environ-mentalpollution								+
Agri-environ-mental programs								
Legend: + complementary objectives, - competitive, - / + potentially both complementary or competitive								

In general the policy objective of subsidy reduction is competitively (negatively) related to the objective of income stability, because subsidies help to ensure the stability of agricultural income. The objective of subsidy reduction is also negatively related to the supply objectives because reduced producer support potentially results in abandoning of UAA and reduction of food and energy production. The relation between subsidy reduction and the environmental objectives can be competitive as well as complementary, due to the potential increased (decreased) intensification of production (cf. Section 1.2) and the effects of land abandoning.

Income stability and the supply objectives are also complementary related. The relation of the objective income stability to environmental objectives can be competitive and complementary, depending if the intensity of production increases or decreases. To aim at the increase of food supply means a competitive relation to energy crop production and vice versa.

Increases in food and energy production imply a complementary relation to the retaining of UAA, whereas increased production is related competitively to the environmental objectives. The retaining of UAA is either competitively or complementary related to the environmental objectives, depending on an intensive or an extensive agricultural management of the area.

The environmental objectives of reduction of production intensity and reduction of environmental pollution are complementary to the other environmental objectives. The application of AEM implies a sustainable and extensive production which potentially decreases the agricultural yields. Thus it is related competitively to the objectives income and food and energy production. Application of AEM aims at landscape management. Therefore the objective of retaining of UAA and environmental objectives are related complementary.

2.1.2 Policy instruments

A public policy instrument is a type of institution for "[…] orienting relations between political society (via the administrative executive) and civil society (via its administered subjects), through intermediaries in the form of devices that mix technical components (measuring, calculating, the rule of law, procedure) and social components (representation, symbol) (Lascoumes and Le Gales 2007: 7). Policy instruments can be "legislative and regulatory, economic and fiscal, agreement- and incentive based, information- and communication-based" (Lascoumes and Le Gales 2007: 5).

The legislative and regulatory framework for the CAP is defined for the EU as a whole (e.g. decoupled direct payments from Pillar 1) and specified for the MS (e.g. the size of decoupled direct payments from Pillar 1). In some cases the MS specify the instruments regionally (e.g. agri-environmental measures).

In this study the policy instruments are simulated by applying different modelling techniques, which are: the change of parameter values (e.g. to simulate changes of direct payments) and the addition of model constraints (e.g. to simulate a limitation of nitrogen input). Table 2.1-2 lists the policy objectives and the relevant instruments to achieve these objectives, which are investigated in this study.

Table 2.1-2: Major instruments to achieve the objectives.

Objectives	Sub objectives	Assumed instruments
Economic	Subsidy reduction	Decoupled direct payments from Pillar 1 and 2
	Income stability	Decoupled direct payments from Pillar 1 and 2
Supply	Food security	Decoupled direct payments from Pillar 1 and 2
	Energy production	Coupled product specific aids
	Retaining of UAA	Direct payments from Pillar 1 and Pillar 2
Environmental	Reduction of production intensity	Direct payments from Pillar 1 and Pillar 2
	Environmental pollution	Legislation for maximal use of nitrogen input
	AEM area	Legislation for compulsory application of AEM

2.1.3 Indicators

"An indicator is a construct, a set of procedures for collecting and combining data to stand in for a concept. […]. It enables one to organise empirical observations, connect them with ideas and give them substance" (De Neufville 1979: 173). In this study indicators are used as tools to measure, describe and discuss the impact of different policy instruments on the context variable (economic, social, structural or environmental) (EC 2006B, OECD 2007A). The range of change provides quantitative information about the impact. The changes are calculated by the value in the simulated policy scenario (SCEN) in comparison either to the reference year (REF) or to the baseline scenario (BL). The reference year (REF) is the base year 2000 under the CAP of Agenda 2000 reform. The baseline scenario (BL or CAP2003) is the simulated year 2015 under assumption of the CAP 2003 reform (cf. Section 1.1). The simulated policy scenarios (SCEN) are scenarios in the year 2015 in which changes in policy or markets are simulated. The calculation of the indicators is summarized in Table 2.1-3. For a more detailed description of the indicators see Appendix 2.1.

The impacts of the simulated policy instruments on the accomplishment of the policy objectives are measured as follows: the economic objectives income and subsidies are measured by changes in the indicators total gross margin and subsidy volume; supply objectives are measured by changes in crop and animal production; environmental objectives are measured by changes in production intensity, changes in input use of nitrogen fertilizer, and changes of area under agri-environmental programs.

The changes in the indicators are determined in two ways:

1. the changes of indicators in the baseline scenario (BL) are calculated as changes between the baseline scenario (BL) and the reference year (REF);

2. the changes of indicators in the policy scenario (SCEN) are calculated as changes between the policy scenario (SCEN) and the baseline scenario (BL);

The term percentage deviation is used to identify the deviation from the reference year (REF). While deviations of the baseline scenario from the reference year are measured in percentage differences for indicators which are not area related (e.g. total gross margin, animal production and nitrogen input) deviations of indicators which are area related (e.g. crop production, intensity, agri-environmental program area) are measured in percentage points. Differences between the policy scenarios (SCEN) and the baseline scenario (BL) are represented in percentage points for all indicators.

To assess the changes in agricultural production resulting from the simulated policy instruments, the baseline scenario and the policy scenarios are compared both with the reference year. The policy scenarios are based on the baseline scenario. Thus, to analyse the effects of the simulated policy instruments in the policy scenarios, the changes in the policy scenarios are compared not with the status of the reference year but with the changes in the baseline scenario (cf. following equations). The advantages of taking this approach for comparison are twofold: firstly, effects resulting from the baseline scenario are excluded and, secondly, the reference year is kept as the common reference point.[7]

$$\text{Deviation between BL and REF} = \frac{BL - REF}{REF} \qquad \text{Eq. 2.1.1}$$

$$\text{Deviation between SC and BL} = \frac{SCEN - REF}{REF} - \frac{BL - REF}{REF} \qquad \text{Eq. 2.1.2}$$

with
REF: reference year
BL: baseline scenario
SCEN: policy scenario

Beside the changes in percentage or percentage points also the average values are compared between the simulated policy scenarios and the reference or baseline scenario. The analysis of average values is used to investigate changes in regional distribution, which is e.g. of interest for changes in the values of the economic indicators income and subsidies or for the environmental indicator nitrogen intensity.

[7] Another approach for comparison often used in policy simulation studies is to use the baseline scenario as counterfactual for the analysis of the policy scenario results.

Table 2.1-3: Overview of the indicators and their definitions.

Major policy objective…	Indicator	Change of …	Unit CAP vs REF/ Unit SCEN vs CAP	Indicator	Definition
Economic objectives	Total subsidy volume	subsidy volume in percent of reference situation	[%]/[pp]	Economic	subsidy volume in SCEN [EUR] /subsidy volume in REF [EUR] * 100
	Subsidy of Pillar 1 payments	dto.	dto.	dto.	dto.
	Subsidy of Pillar 2 payments	dto.	dto.	dto.	dto.
	TGM volume	total gross margin volume in percent of reference situation	[%]/[pp]	Economic	total gross margin volume in SCEN [EUR]/total gross marginvolume in REF [EUR] * 100
Supply objectives	Cereals area	cereals area in percentage point of UAA	[pp]/[pp]	Food production	percentage of cereals area in SCEN [% of UAA] - percentage of cereals area in REF [% of UAA]
	Maize area	maize area in percentage point of UAA	[pp]/[pp]	Food production	dto.
	Fodder crops area	fodder crop area in percentage point of UAA	[pp]/[pp]	Food production	dto.
	Others area	other crops in percentage point of UAA	[pp]/[pp]	Food production	dto.
	Conv. GL into AL	area, which is converted from grassland into arable land in percentage point of UAA	[pp]/[pp]	Food production	dto.
	Conv. AL into GL	area, which is converted from grassland into arable land in percentage point of UAA	[pp]/[pp]	Food production	dto.
	Intensive GL	intensive grassland area in percentage point of UAA	[pp]/[pp]	Food production	dto.
	Extensive GL	extensive grassland area in percentage point of UAA	[pp]/[pp]	Food production	dto.
	Not fodder GL	grassland area, which is not ued for fodder produciton in percentage point of UAA	[pp]/[pp]	Food production	dto.
	Abandoned UAA	area which falls abandoned in percentage point of UAA	[pp]/[pp]	Food production	dto.
	Dairy cows	number of dairy cows in percent of reference situation	[%]/[pp]	Food production	number of animals in SCEN [#] /number of animals in REF [#] * 100
	Fattening bulls	number of fattening bulls in percent of reference situation	[%]/[pp]	Food production	
	Fattening pigs	number of fattening pigs in percent of reference situation	[%]/[pp]	Food production	
	Energy maize	energy maize area in percentage point of UAA	[%]/[pp]	Energy production	percentage of cereals area in SCEN [% of UAA] -percentage of cereals area in REF [% of UAA]

Major policy objective…	Indicator	Change of …	Unit CAP vs REF/ Unit SCEN vs CAP	Indicator	Definition
Envrionmental objectives	Int. crops area	area with intensive crops in percentage point of UAA	[pp]/[pp]	Production intensity	dto.
	Int. variants area	area with intensive crop variants in percentage point of UAA	[pp]/[pp]	Production intensity	dto.
	Nitrogen intensitiy	intensity of nitrogen input	[%]/[pp]	Environmental impacts	Nitrogen amount per hectares in SCEN [kg ha^{-1}] / Nitrogen amount per hectares in REF [kg ha^{-1}] * 100
	Erosion factor	erosion potential	[pp]/[pp]	Environmental impacts	erosion factor in SCEN [%] -erosion factor in REF [%]
	GHG emissions	CO_2 equivalents	[%]/[pp]	Environmental impacts	CO_2 equivalent in SCEN [t]/CO_2 equivalent in REF [t] * 100
	Weighted nitrogen and erosion	Weighted nitrogen and erosion	[%]/[pp]	Environmental impacts	Weighted Potential = Potential not weighted * 60% * Share of intercrops of UAA
	AEM area of total UAA	of area with agricultural environmental measures	[%]/[pp]	Agro environmental programms	area under AEM [ha^{-1}] in SCEN-average AEM payments [ha^{-1}] in REF * 100
Notes: REF: Reference year, CAP: CAP 2003 reform scenario, SCEN: other policy scenarios					

Interpretation of changes in indicator values

Table 2.1-4 presents a summary on how policy induced changes in indicator values are interpreted. The table presents the change of the indicator value in the case that a desired (declared) development of an objective is indicated. For example, on the one hand a decrease in the value of the indicator subsidy volume would result in a positive (desired) development in public expenditure. On the other hand, a positive development of total gross margin (agricultural income) is associated with an increase or no change in the subsidy volume. The impact of increasing subsidies on production intensity is not strait forward because the expected reaction of farmers can be an increase as well as a decrease of intensity or even the abandoning of farming (the latter especially if the subsidies are not coupled to production).

Table 2.1-4: Indicated impact of a change in indicator value on the policy objective in case of a desired development for the objectives.

Indicator	Unit	Description	Reduction of subsidies	Income stability	Food security	Energy crop production	Retaining of UAA	Production intensity	Environmental pollution	Participation in Environmental Programs
Desired change for the objective:			**-**	**0/+**	**0/+**	**0/+**	**0/+**	**0/-**	**0/-**	**0/+**
SUBvol[m]	EUR ha^{-1}//%	average total SUBvol[m] / change of SUBvol[m]	-	=/+	=/+	=/+	=/+	n.i.	n.i.	n.i.
TGM[n]	EUR ha^{-1}//%	average TGM[n] volume/ change of TGM[n]	-/=/+	=/+	n.i.	n.i.	n.i.	n.i.	n.i.	n.i.
Cereals	%UAA/pp[o]	share/change of cereals area	n.i.	=/+	=/+	n.i./-	+	-	-	n.i.
Grain maize	%UAA/pp[o]	share/change of grain maize area	n.i.	=/+	=/+	n.i./-	+	-	-	n.i.
Energy maize	%UAA/pp[o]	share/change of energy maize area	n.i.	+	-	+	+	-	-	n.i.
Fodder crops	%UAA/pp[o]	share/change of fodder crop area	n.i.	=/+	=/+	n.i./-	+	-	-	n.i.
Others area	%UAA/pp[o]	other crops area	n.i.	=/+	=/+	n.i./-	+	-	-	n.i.
Conv. of grassland[q]	%UAA/pp[o]	share/change of conv. of grassland[q]	+	+	+	+	+	-	-	-
Conv. of arable land[r]	%UAA/pp[o]	share/change of conv. of arable land[r]	-	-	-	-	-	+	+	+
Intensive grassland	%UAA/pp[o]	share/change of intensive grassland	-	+	-/+	-	+	-	-	-
Extensive grassland	%UAA/pp[o]	share/change of extensive grassland	-	+	-	-	+	+	+	+
Abandoned UAA[s]	%UAA/pp[o]	share/change of intensive crop area	=/-	=/-	=/-	=/-	-/=	+	+	-/=
Intensive crop area	%UAA/pp[o]	share/change of intensive crop area	n.i.	+	+	n.i.	n.i.	-	-	-
Intensive variant area	%UAA/pp[o]	share/change of intensive variant area	n.i.	+	+	n.i.	n.i.	-	-	-
Dairy cows	# ha^{-1} /%[t]	cow density / numbers of cows	n.i.	=/+	=/+	n.i./-	+	-	-	n.i.
Bulls	# ha^{-1} /%[t]	bulls density / numbers of bulls	n.i.	=/+	=/+	n.i./-	+	-	-	n.i.
Fattening pigs	# ha^{-1} /%[t]	pig density / numbers of pigs	n.i.	=/+	=/+	n.i./-	+	-	-	n.i.

Indicator	Unit	Description	Reduction of subsidies	Income stability	Food security	Energy crop production	Retaining of UAA	Production intensity	Environmental pollution	Participation in Environmental Programs
Desired change for the objective:			**-**	**0/+**	**0/+**	**0/+**	**0/+**	**0/-**	**0/-**	**0/+**
Nitrogen intensity	kg ha^{-1}/ %	Nitrogen input applied in agricultural production	n.i.	n.i.	+	n.i.	n.i.	-	-	n.i.
Erosion potential	%pot/%[v]	erosion potential	n.i.	n.i.	n.i.	n.i.	n.i.	-	-	-
GHG[w] emissions	kg ha^{-1}/%	GHG emissions	n.i.	n.i.	n.i.	n.i.	n.i.	-	-	-
Potential AEM area[x]	%UAA/pp[o]	area with AEM applied potentially	n.i. -/=	n.i. -/=	-/=	-/=	+	+	+	+

Notes: a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percent share of UAA/percentage points of UAA compared to the share in reference situation. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare/difference in percent. u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. v: Potential in percent of uncovered arable land/difference in percent. w: Green house gas. x: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. =: unchanged; +: increasing; - : decreasing; 0: neutral; n.i.: no clear indication.

2.2 Regional analysis framework for agricultural production in the study region

Agricultural production in Baden-Wuerttemberg is of high importance and regionally heterogeneous due to differing natural conditions. Almost half (46%) of the total area is agricultural area (i.e. 1.65 Mio. ha out of 3.58 Mio. ha) (LEL 2007). The share of arable land of UAA is 58%, the share of grassland is 38% and 3% are used for production of permanent crops as fruit and wine. The most important livestock products are dairy, beef and pork.[8] This chapter describes the agricultural production in the study region in the reference year as well as the regional analysis framework which is used to analyze the study results. In this study the agricultural producers are represented by so called 'regional farms'. Regional farms are single farms representing the agricultural production of an entire sub-region. Sub-regions of the model region Baden-Wuerttemberg are defined as NUTS3 counties. Therefore the production factors of all producers in the respective sub-region are aggregated in one single regional farm.

Subsection 2.2.1 describes Baden-Wuerttemberg's regional agricultural production conditions with respect to natural regions and according to administrative regions at NUTS3 county scale. Supply indicators as well as the resulting economic and environmental indicators for the NUTS3 counties are described in Subsection 2.2.2. Farm types, which serve as clusters for comparable NUTS3 counties, are introduced in Subsection 2.2.3. The farm types are used in order to analyse the study results in a more general than regional way. Subsection 2.2.4 describes the values of indicators in the farm types under consideration of possible impacts of policy scenarios. Conclusions for the regional analysis framework are drawn in Subsection 2.2.5.

2.2.1 Regional agricultural production conditions in Baden-Wuerttemberg

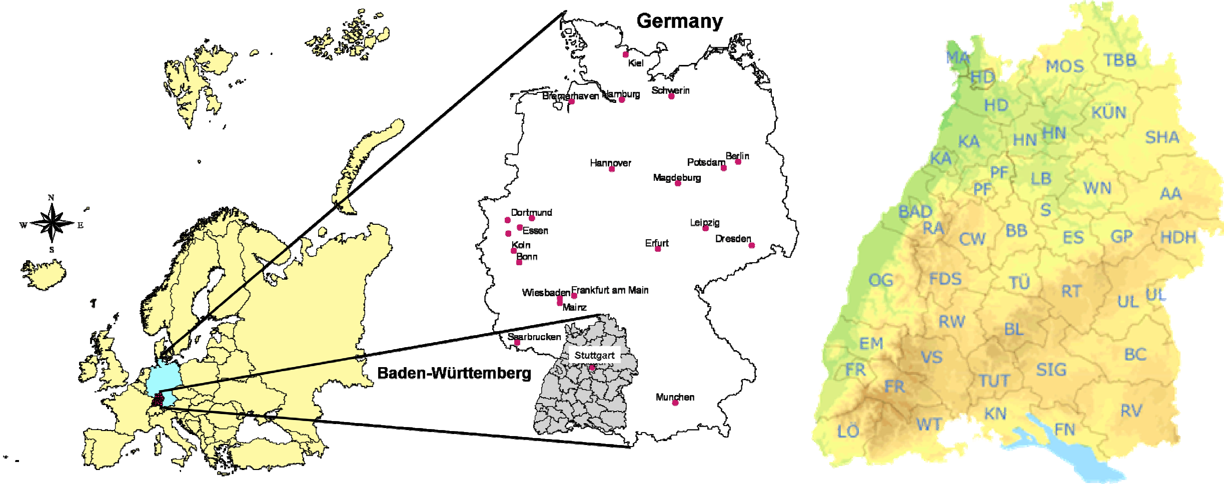
Topographic conditions in Baden-Wuerttemberg

Baden-Wuerttemberg is located in middle Europe in South-Western Germany. The climate is continental and soil fertility depends on geological conditions reaching from less favoured mountain areas to fertile valleys and river plateaus. Figure 2.2-1 presents the location of

[8] For more detailed information of agricultural production in Baden-Wuerttemberg see Appendix 2.2.

Baden-Wuerttemberg in Europe and in Germany as well as its topographic conditions. Along the west side of the region, in the Rhine valley, fertile soils and warm climate allow intensive farming of arable crops and special crops. Also the plateau in the north is dominated by intensive arable cropping. From the southern part of the region the mountains Schwarzwald and the Schwäbische Alp diverge in a V-shape. Here soils are less fertile and production is dominated by extensive grassland farming. In the south-western part of the region, in the Alpenvorland, high rates of precipitation allow intensive grassland production. In the area around the Lake of Constance the production of special crops (fruits and vegetables) is possible due to the warm climate.

Figure 2.2-1: Geographical location (left) and topographical map (right) of Baden-Wuerttemberg.



Administrative regions in Baden-Wuerttemberg

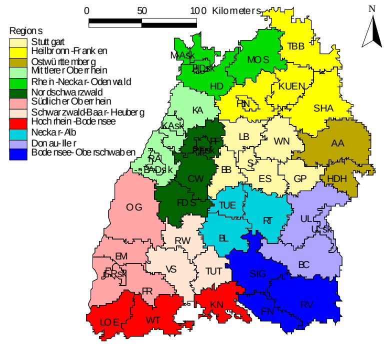
In the terminology of the Nomenclature of Territorial Units for Statistics (NUTS[9]), the federal state Baden-Wuerttemberg is a NUTS1 region and it consists of four NUTS2 districts: Stuttgart (S), Karlsruhe (KA), Freiburg (FR) and Tuebingen (TUE). The next smaller regional units are the 44 NUTS3 counties out of which 8 are city counties of high population density and small regional extension. The next smaller level is represented by the 1101 municipalities (NUTS4 level). Due to censor issues the data at NUTS4 level are not complete; crop acreages and livestock data are not fully provided, crop and crop yield data are not provided at all. Therefore the quality of the statistical data at NUTS4 level is not sufficient to be used in this study. In contrast, statistical data for agricultural production at NUTS2 and NUTS3 level are available in suitable quality and are chosen in this study as the regional basis to create regional farms. The NUTS3 counties in Baden-Wuerttemberg are grouped by 12 different

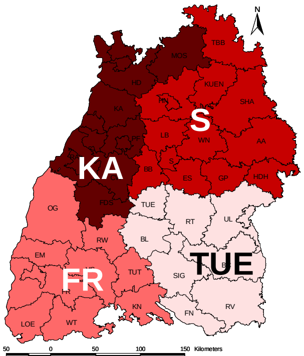
[9] The abbreviation is derived from the French term "Nomenclature d'unités territoriales statistiques".

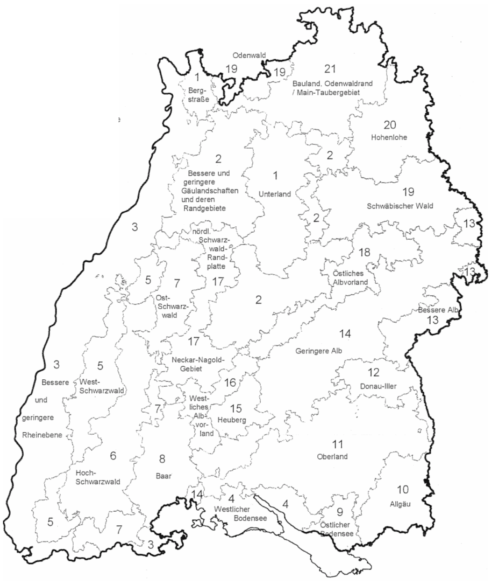
'administrative regions' listed in Figure 2.2-2[10]. The regions are classified according to the requirements of regional and landscape planning. Within 'administrative regions' the agronomic conditions are quite heterogeneous with respect to geographic, topographic and climatic conditions (MLR 2008A: 59). Because of this heterogeneity, the 'administrative regions' are not suitable as spatial regions to simulate regional agricultural production.

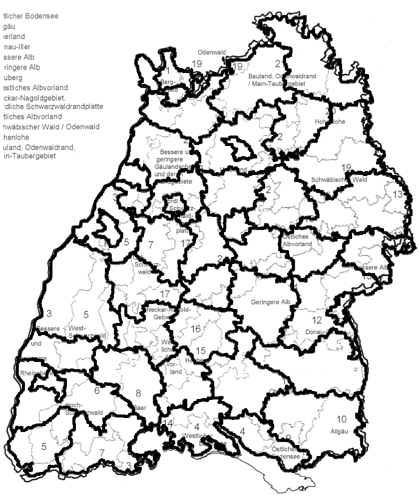
[10] For an enlarged presentation of these maps see Appendix 2.2.

Figure 2.2-2: Administrative regions, NUTS3 counties, NUTS2 districts and natural regions of Baden-Wuerttemberg.









Administrative region		NUTS3 county		IDID
Stuttgart	1	SK Stuttgart	S	8111
		LK Boeblingen	BB	8115
		LK Esslingen	ES	8116
		LK Goeppingen	GP	8117
		LK Ludwigsburg	LB	8118
		LK Rems-Murr-Kreis	WN	8119
Heilbronn -Franken	2	SK Heilbronn	HNsk	8121
		LK Heilbronn	HN	8125
		LK Hohenlohekreis	KUEN	8126
		LK Schwaebisch Hall	SHA	8127
		LK Main-Tauber-Kreis	TBB	8128
Ostwürt- temberg	3	LK Heidenheim	HDH	8135
		LK Ostalbkreis	AA	8136
Mittlerer Oberrhein	4	SK Baden-Baden	BAD	8211
		SK Karlsruhe	KAsk	8212
		LK Karlsruhe	KA	8215
		LK Rastatt	RA	8216
Rhein- Neckar	5	SK Heidelberg	HDsk	8221
		SK Mannheim	MAsk	8222
		LK Neckar-Odenwald-Kreis	MOS	8225
		LK Rhein-Neckar-Kreis	HD	8226
Nord- schwarz- wald	6	SK Pforzheim	PFsk	8231
		LK Calw	CW	8235
		LK Enzkreis	PF	8236
		LK Freudenstadt	FDS	8237
Südlicher Oberrhein	7	SK Freiburg i.Breisgau	FRsk	8311
	7	LK Breisgau-Hochschwarzwald	FR	8315
		LK Emmendingen	EM	8316
		LK Ortenaukreis	OG	8317
Schwarz- wald- Baar- Heuberg	8	LK Rottweil	RW	8325
		LK Schwarzwald-Baar-Kreis	VS	8326
		LK Tuttlingen	TUT	8327
Hochrhein- Bodensee	9	LK Konstanz	KN	8335
		LK Loerrach	LOE	8336
		LK Waldshut	WT	8337
Neckar-Alb	10	LK Reutlingen	RT	8415
		LK Tuebingen	TUE	8416
		LK Zollernalbkreis	BL	8417
Donau-Iller	11	SK Ulm	ULsk	8421
		LK Alb-Donau-Kreis	UL	8425
		LK Biberach	BC	8426
Bodensee- Obers- chwaben	12	LK Bodenseekreis	FN	8435
		LK Ravensburg	RV	8436
		LK Sigmaringen	SIG	8437

Notes: upper map on the left: administrative regions; upper map on the right: NUTS2 districts; middle map: natural regions (Vergleichsgebiete); lowest map: NUTS3 counties mapped with Vergleichsgebiete.

Agronomic regions: Vergleichsgebiete and Vergleichsgebietgruppen according to MLR (2008A: 54-58)[11]

The classification Vergleichsgebiete (VG) comprises spatial regions with comparable agronomic production potential due to similar topographical and climatic conditions. Spatial differences within the Vergleichsgebiete are caused by heterogeneities due to different soil characteristics (MLR 2008A: 63). The borders of the Vergleichsgebiete are derived from natural landscape or topography borders; thus they are not congruent with the borders of the administrative NUTS3 counties. The 21 Vergleichsgebiete are aggregated in 8 Vergleichsgebietsgruppen (VGG). VGG and VG are briefly described below with respect to their agricultural land use and with respect to the NUTS3 counties they are covering (MLR 2008A: 63ff). Table 2.2-1 summarizes the information and adds the data of soil type.

The VGG Unterland/Gäue (VGG 1) comprises the VG Unterland Bergstrasse (VG 1) and VG Gäulandschaften (VG 2). In these VG the most fertile soils area in Baden-Wuerttemberg are found and the climate is warm enough to produce cereals, grain maize, sugar beet as well as vegetables, vine and fruits.

The VGG Rhein/Bodensee (VGG2) comprises the Vergleichsgebiete VG Rheinebene (VG 3), VG Westlicher Bodensee (VG 4) and VG Östlicher Bodensee (VG 9). The different soils allow the production of maize, cereals, fodder crops, fruit and wine.

The VGG Schwarzwald (VGG 3) consists of the Vergleichsgebiete Westschwarzwald (VG 5), Hochschwarzwald (VG 6) and Ostschwarzwald (VG 7). The soil quality and good climatic conditions in VG Westschwarzwald (VG 5) allow the production of cereals and potatoes up to 1000 m altitude but it is of minor importance. In VG Hochschwarzwald (VG 6) low soil fertility and the high altitude let grassland farming dominate agricultural production. Arable cropping is not significant. Due to better soil fertility in VG Ostschwarzwald (VG 7) arable cropping has a higher importance than in VG Hochschwarzwald.

VGG Alb/Baar (VGG 4) covers the VG Baar, Geringer Alb (VG 14), Heuberg (VG 15) and Westliches Alpvorland (VG 16). VG Baar (VG 8) is the plateau in between Schwarzwald and Schwäbische Alp and it is characterized by a high heterogeneity of soils. Cereals production and fodder crops are the main arable land crops. VG Geringere Alb (VG 14) is the plateau of the mountain Schwäbische Alp. The soils are of thin agronomic usable layers and are very

[11] The following description of the "Vergleichsgebiete" and "Vergleichsgebietsgruppen" is a translation of: MLR, 2008A. Landwirtschaftliche Betriebsverhältnisse und Buchführungsergebnisse, Wirtschaftsjahr 2006/07, Volume 56. Ministerium für Ernährung und Ländlichen Raum Baden-Württemberg (MLR). pp. 54-58.

permeable for water. Thus, they allow only extensive production of cereals and fodder crops. VG Heuberg (VG 15) is a higher altitude of the Westalp. The soil here is of high permeability for water, which makes cropping of cereals and fodder crops possible despite high precipitation, however this results in strong yields fluctuations.VG Westliches Alpvorland (VG 16) in the west of the Alps is dominated by large grassland areas.

VGG Allgäu (VGG 5) consists only of the VG Allgäu (VG 10) and is dominated by grassland farming.

The VGG Oberland/Donau (VGG 6) includes VG Oberland (VG 11), VG Donau-Iller (VG 12) and VG Bessere Alb (VG 13). In VG Oberland (VG 11) soil fertility and climatic conditions allow high shares of arable cropping with cereals and fodder crop production. In VG Donau-Iller (VG 12) climate and soil fertility in the Danube valley and in the Iller valley makes it possible to produce grain maize and sugar. The VG Bessere Alb (VG 13) in the South-East of the Schwäbischen Alp is characterized by deep horizonted fertile soils and the good climatic conditions which allow intensive arable cropping of cereals and fodder crops.

VGG Albvorland/Schwäbischer Wald (VGG 7) consists of VG Neckar-Nagold-Gebiet (VG 17), VG Östliches Albvorland (VG 18) and VG Schwäbischer Wald/Odenwald (VG 19). In VG Neckar-Nagold-Gebiet (VG 17) soils are different in north and south and they are suitable for production of cereals and fodder crops. In VG Östliches Albvorland (VG 18) cropping of cereals and fodder crop production, grain maize is possible. VG Schwäbischer Wald/Odenwald (VG 19) is a hilly forest area where on arable land cereals and fodder crop are produced.

VGG Bauland/Hohenlohe (VGG 8) consists on VG Hohenhlohe and VG Bauland, Odenwaldrand and Taubergebiet. In VG Hohenlohe (VG 20) cereals and fodder crop production is possible on heavy soils. In favourable areas also fruit and wine are produced. In VG Bauland, Odenwaldrand und Taubergebiet (VG 21) the main arable crops are cereals and fodder crops. In favourable areas the soils allow also the production of sugar beet and grain maize.

Table 2.2-1: Characteristics of the Vergleichsgebiete in Baden-Wuerttemberg.

Vergleichsgebietgruppen (VGG)	Vergleichsgebiete (VG)	Counties	Crops	Climate	Soils
Unterland/Gäue (VGG 1)	VG Unterland Bergstrasse (VG 1)	Heilbronn (HN), Ludwigsburg, Stuttgart, Rhein-Neckar-Kreis	cereals, grain maize, sugar beet vegetables, vine, fruit	warm climate	based on Muschelkalk, Keuper, covered by Löss of different altitude most fertile soil in BW
	Gäulandschaften (VG 2)	Kraichgau, Filderebene, Neckartal Rems-Murr-Kreis, large areas of Hohenlohekreis	grain maize, cereals, sugar beet, potatoes, vine and fruit		based on Muschelkalk and Keuper and Schwarzjura with differentiating layers of Löss
Rhein/Bodensee (VGG 2)	VG Rheinebene (VG 3)	Hochrheingebiet from Waldshut Mannheim (MLR 2008A: 63), covering nearly 50%. Lörrach, Breisgau-Hochschwarzwald, Emendingen, Ortenaukreis, Rastatt, Baden-Baden, Karlsruhe and Rhein-Neckar-Kreis	arable cropping form of cash crops, fodder crops special crops		Reache from sand mixed with Kies based on alluvial Schwemmlandböden to Lehm, Ton and Lößböden
	Westlicher Bodensee (VG 4)	grain maize, cereals, fodder crop production well as fruit and wine			Eiszeitmoränen Böden
	Östlicher Bodensee (VG 9)	VG and allows as Westlicher Bodensee (VG 4) and the comparable VG Östlicher Bodensee (VG 9) cover large parts of Konstanz and Bodenseekreis			
VGG Schwarzwald (VGG 3)	Westschwarzwald (VG 5)				Buntsandstein, Granit and Gneis, covered by thin layers of lehmigen Sandböden
	Hochschwarzwald (VG 6)	the high altitude, and low soil fertility	grassland farming dominate agricultural production, arable cropping is not significant		based on mittlerer Buntsandstein, Granit and Gneis
	Ostschwarzwald (VG 7)	Enzkreis, Calw, Freudenstad, Rottweil, Schwarzwald-Baar-Kreis	arable cropping has a higher importance than in Hochschwarzwald	due to better soil climate index	Buntsandstein
VGG Alb/Baar (VGG 4)	Baar (VG 8)	VG Baar includes parts of Tuttlingen and Rottweil	cereals production and fodder crops are the main arable land crops		significant heterogenity of soils due: Muschelkalk, Keuper, Schwarzjura and Braunjura
	Geringere Alb (VG 14)	largest part of Reutlingen, Göppingen, Ostalpkreis, bordering on Sigmaringen, Zollernalbkreis, Tübingen, Esslingen	production of cereals and fodder crops		plateau of the Schwäbische Alp Weißjuraverwitterungsböden Soils small agronomic usable layers and very permeable to water
	Heuberg (VG 15)		cropping of cereals and fodder crops is possible, with strong yield fluctuations	higher altitude	high precipitation soil of high permeability to water

Vergleichsgebietgruppen (VGG)	Vergleichsgebiete (VG)	Counties	Crops	Climate	soils
VGG Alb/Baar (VGG 4)	Westliches Alpvorland (VG 16)	areas of Tuttlingen, Rottweil and Zollernalbkreis	grassland area is dominating		Braunjura soil in the west of the Alps
VGG Allgäu (VGG 5	VG Allgäu (VG 10)	Eastern part of Ravensburg , bordering on Bodenseekreis and Biberach	dominated by grassland farming		no information in MLR (2005)
Oberland/Donau (VGG 6)	VG Oberland (VG 11)	covering large shares of Ravensburg, Sigmaringen, Biberach and Tuttlingen, bordering on Alp-Donau-Kreis and Konstanz	high shares of arable land with cereals and fodder crop	good climatic conditions	moraine landscape
	VG Donau-Iller (VG 12)	Danube valley and Iller valley Alp-Donau-Kreis and borders on Biberach	grain maize sugar beet.	climatic good conditions	alluvialen Lehm- and Tonböden
	VG Bessere Alb (VG 13)	located in the South-East of the Schwäbischen Alp Heidenheim and Alp-Donau-Kreis	intensive arable cropping for cereals and fodder crops areas in	climatic good conditions	Weisjuraverwitterungsböden with deep horizont
Albvorland/Schwäbischer Wald (VGG7)	Neckar-Nagold-Gebiet (VG 17),	Rottweil, Freudenstadt, Zollernalbkreis	dominating crop production cereals ,fodder crops		in the north: Muschelkalk- and Keuper layers, in the south: Buntsandstein, partially covered by Löss
	Östliches Albvorland (VG 18)	crosses Tübingen, Reutlingen, Esslingen, covers larger shares of Göppingen and Ost-Alp-Kreis.	production dominate arable cropping Cereals and fodder crop. areas production of grain maize is possible In favourable		in the south: Schwarz- and Braunjura, in the north: Keuper
	Schwäbischer Wald/Odenwald (VG 19)	Rems-Murr-Kreis, Ostalpkreis, Schwäbisch Hall and Hohenlohekreis, small share of Odenwald is located in Rhein-Neckar-Kreis and in Neckar-Odenwald-Kreis.	forest area with cereals and fodder crop production	the area is a hilly forest area	Keuper in Schwäbischer Wald, Buntsandstein in Odenwald
Bauland/Hohenlohe (VGG 8)	Hohenlohe (VG 20)	Schwäbisch Hall, Hohenlohekreis and Main-Tauber-Kreis.	dominating arable cropping: cereals and fodder crops in favourable areas fruit, wine		heavy soils based on Muschelkalk and Keuper
	Bauland, Odenwaldrand und Taubergebiet (VG 21)	large shares of Main-Tauber-kreis, Neckar-Odenwald-Kreis, bordering on Heilbronn and Hohenlohekreis.	mainly cereals, fodder crops: sugar beet and grain maize is in favoured areas also production		Muschelkalk, Keuper, covered partially by Lößlayers

Source: MRL (2008A)

Natural conditions in the NUTS3 counties

While agricultural production data are available at NUTS3 level, data to describe the natural conditions are available for the spatial regions Vergleichsgebiete (VG). As the natural borders of the VG are not congruent with the administrative borders of the NUTS3 counties information of natural conditions for agricultural production cannot be directly applied to NUTS3 counties. Consequently, in order to explain agricultural production at NUTS3 level the data of geological, topographical and climate conditions of the VG have to be transferred to the NUTS3 counties level.

The natural conditions of the VG are represented by the items of altitude, annual average temperature, and annual precipitation. To represent theses data mean values are calculated of minimum and maximum values provided by MRL (2008A).

In order to represent the data of the VG by the not congruent NUTS3 counties the data for the VG are weighted by the shares of area. The percentage shares of area of NUTS3 counties belonging to the VG are estimated. These percentage shares are used to weight the average values of the data on natural conditions in the VG. The weighted data were summed up to the data which represent the NUTS3 counties.

The following example illustrates the way of calculation: The weighted average temperature of the NUTS3 county Sigmaringen (SIG) is calculated by estimating that 75% of the area in SIG is covered by the area of VG Oberland and 25% by the area of VG Geringere Alp (see map in Figure 2.2-1). As in Oberland the average temperature is 7.25 degrees Celsius and in Geringere Alp 6.5 degrees Celsius this results in a weighted temperature for SIG of 7.06 degrees Celsius (25% * 6.5 + 75% * 7.25 = 7.06). It has to be noted that the weighting is only an approximation[12], because in reality also a small share of a third Vergleichsgebiet (Oestliches Alpvorland) covers SIG in the North Western part.

Maps 2.3-2-a to c present the geological, topographical and climatic conditions as they are transferred from the VG to NUTS3 counties. The map presenting the altitudes is comparable with Map 2.2-1 which presents the altitudes with a more exact geographic resolution than the NUTS3 maps. In the north and in the north-western quarter of Baden-Wuerttemberg the NUTS3 counties are of small altitude with 300 to 400 m. The south western quarter and the eastern half of the region are higher, with 400 to 600 m. The two highland regions with more

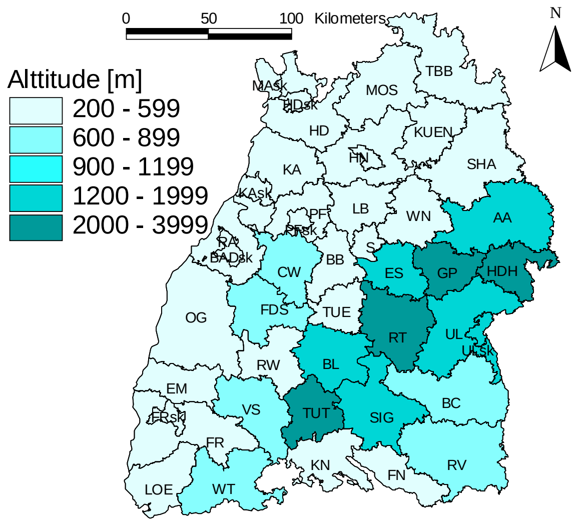
[12] A more exact estimation would be provided by a calculation based on municipality level (NUTS 4) which are attributed to the Vergleichsgebiete. However, these data were not available at the time the analysis was conducted.

than 1000 m are crossing in the south east: the Schwarzwald in the east and the Alp in the west.

The Maps 2.3-2-a to c show that the higher regions are of smaller annual temperature, while the lowland region in the north-west and around the Lake of Constance (KN and FN) are of relative warm climate. Precipitation tends to be smaller in the low land region in the north eastern part than in the higher regions (Map 2.2-1 b). The NUTS3 counties in front of the high mountain regions Schwarzwald (e.g. FR, LOE) and the Alps (e.g. RV) are of higher precipitation. In RV the Lake of Constance influences as water reservoir the precipitation.

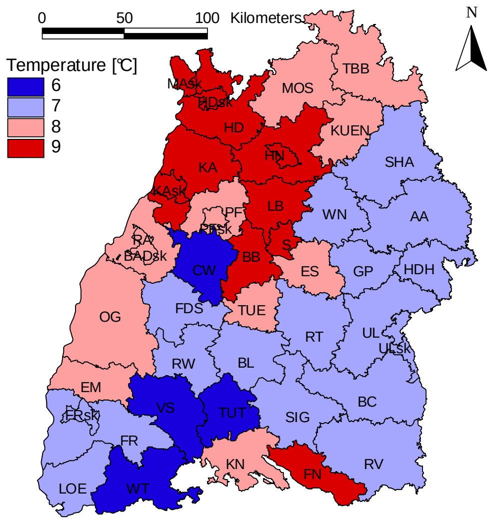
Map 2.2-1 d presents the soil climate index. The soil climate index represents the natural yield conditions which are determined by geographic (soil, slope) and climate (water, temperature) conditions. The soil climate index is available at NUTS3 level and can be directly used to explain land use and crop production at NUTS3 level.

Map 2.2-1 a: Average altitude in metres transferred from weighted values of the VG.



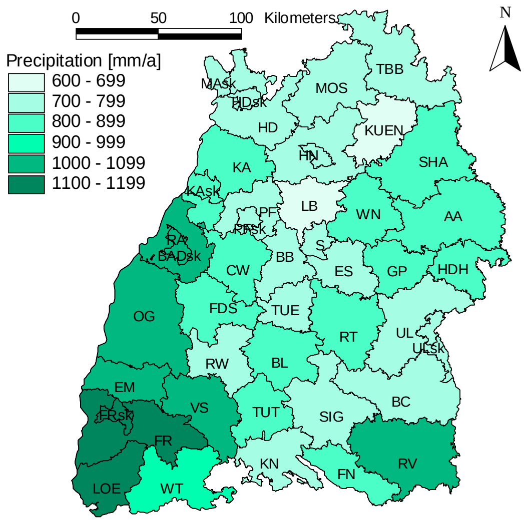
Notes: Unit: m.

Map. 2-3-1 b: Average annual temperature in degree Celsius.



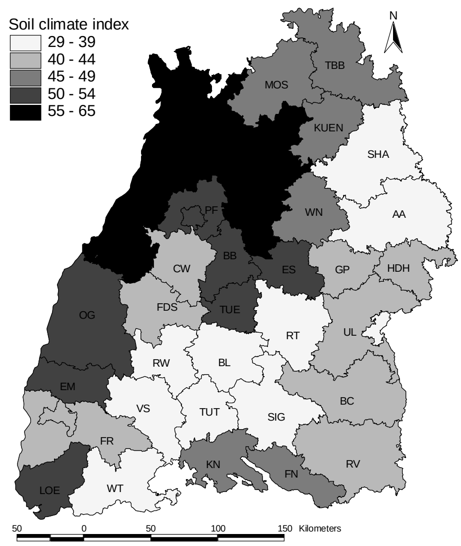
Notes: Unit: degree Celsius.

Map 2.2-1 c: Average annual precipitation.



Notes: Unit: mm a^{-1}.

Map 2.2-1 d: Soil climate index.



Notes: Unit: index figure.

2.2.2 Production, economic and environmental situation at NUTS3 level in the reference year

For the administrative unit of NUTS3 counties data of agricultural production are provided by the Statistical Office of the federal state Baden-Wuerttemberg. The NUTS3 level data are suitable to describe agricultural production in the study region at a regional level and are used to calibrate the supply model.

The agricultural production situation presented in this section provides the reference situation in the reference year 2000.[13] First, the regional agricultural production resulting from the natural condition is described, and then the economic and the environmental indicators resulting from the agricultural production are presented.

[13] The reference year represents the statistical situation in the base year. Small marginal deviations, result from optimisation process and are negligible. In comparison with other sources there might be deviations between the statistical data, e.g. regarding animal density. These negligible differences result from the fact that the values are model results calculated by an optimization model, while values from other sources might result from directly observed/counted data.

Supply indicators

Natural conditions for crop production

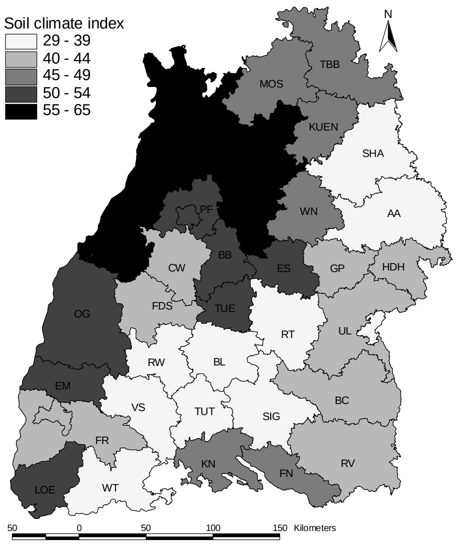
Map 2.2-1 d presents again the soil climate index at NUTS3 scale in order to facilitate its comparison with land use distribution. Map 2.2-3 a and Map 2.2-3 b present the share of grassland in the counties. In VGG Rhein/Bodensee and in VGG Unterland/Gäue the soil climate index is high (> 50), with the most fertile soils in the latter region (LVZ > 55). Land use here is characterized by intensive arable cropping indicated by high percentage of cash crop production and only small percentage of grassland. These fertile regions are characterized by relatively high temperatures and low precipitation (cf. Map 2.2-1 b and Map 2.2-1 c).

In the area of Rheinebene the high annual precipitation (cf. Map 2.2-1 c) provokes a higher share of grassland usage. The NUTS3 counties in the east of the region have a lower soil climate index with between 45 and 49. These VGG of Albvorland/Schwäbischer Wald and Bauland/Hohenlohe show also small percentages of grassland. Here, arable land is used for cash crop production and relative high shares of fodder crop production (10 to 14% of UAA) (cf. Maps 2.2-3 c and d).

NUTS3 counties with extremely high grassland shares are found in VGG Schwarzwald, in VGG Alb/Baar and in VGG Allgäu, due to climatic conditions and a low soil quality of the mountainous regions. The soil climate index and the temperatures are lower while the precipitation is higher than in the counties of plateaus or in valleys (cf. Map 2.2-1 a). Grassland usage is differentiated in intensive and extensive grassland farming which is presented in Maps 2.2-1 e and 2-2-1 f. The majority of the grassland counties are dominated by extensive grassland areas, particularly in the counties of the mountainous regions Schwarzwald and Schwäbische Alb. The three counties Emmendingen, Freiburg-Breisgau, Lörrach and Ravensburg show a higher share of intensive grassland areas. Here, the annual precipitation is higher than in the other grassland counties (cf. Map 2.2-1 c).

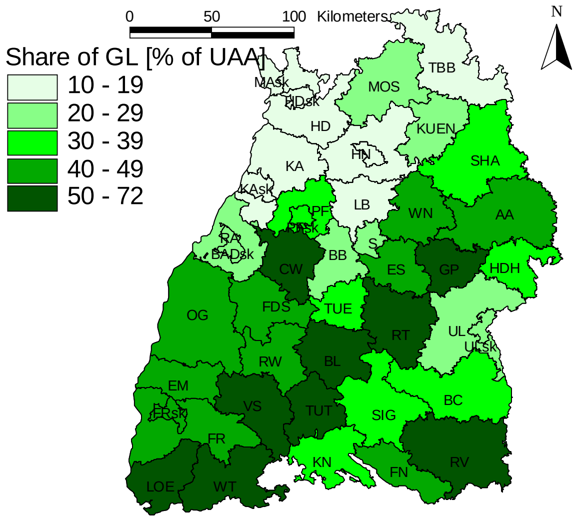
In NUTS3 counties with high soil climate index and warm climate the share of food crops is relatively high (e.g. in the north-western part, KA, HB). In regions with lower soil climate index the share of fodder crop production is relatively high (e.g. in the western edge of the region in the NUTS3 counties AA and HDH). In following arable crop production is presented more detailed in different crop categories: cereals, maize, root crops, special crops, silage maize and clover.

Map 2.2-2 a: Soil climate index.



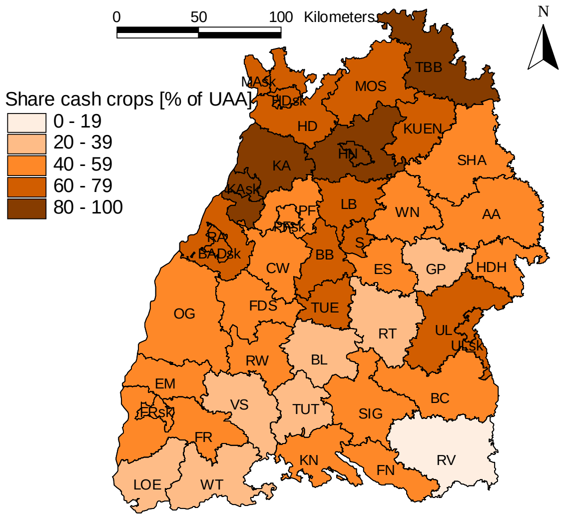
Notes: index figure.

Map 2.2-2 b: Percentage share of grassland.



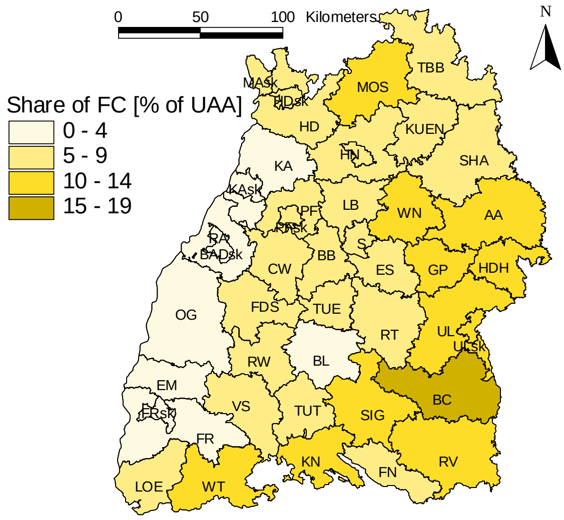
Notes: Unit: % UAA.

Map 2.2-2 c: Percentage share of cash crops in REF.



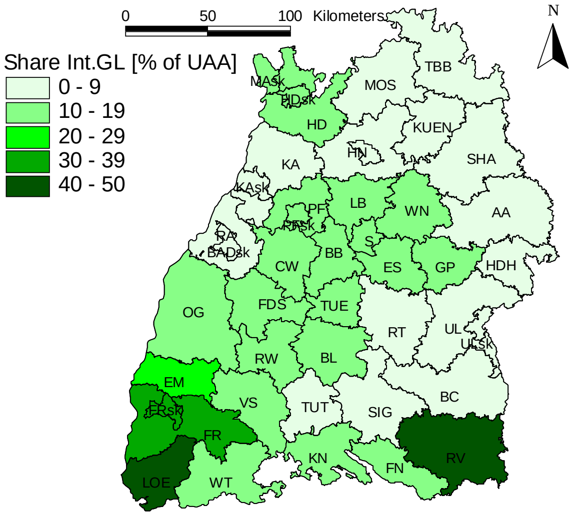
Notes: Unit: % UAA.

Map 2.2-2 d: Percentage share of fodder crops in REF.



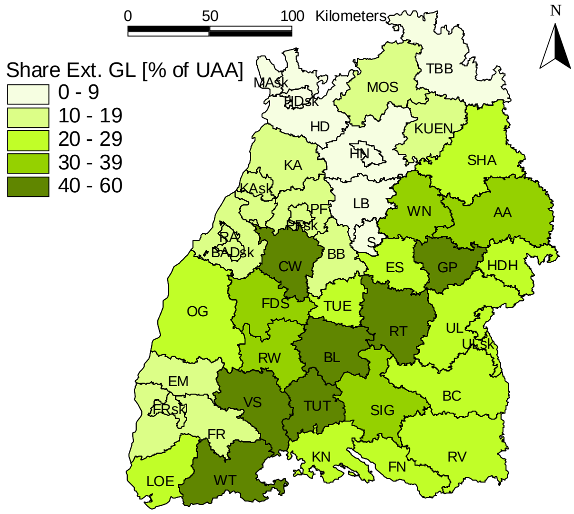
Notes: Unit: % UAA.

Map 2.2-2 e: Percentage share of intensive grassland in REF.



Notes: Unit: % UAA.

Map 2.2-2 f: Percentage share of extensive grassland in REF.



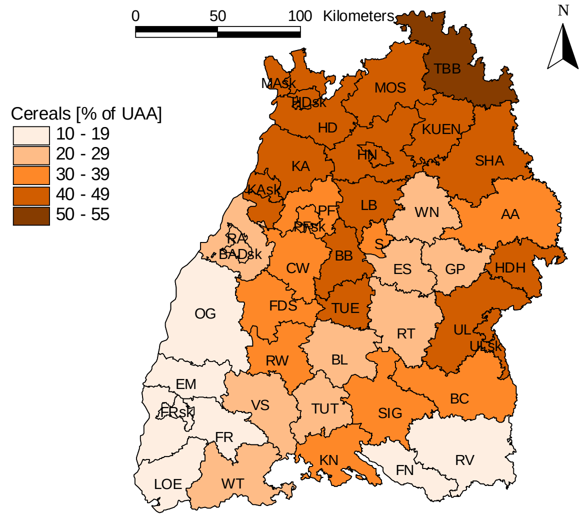
Notes: Unit: % UAA.

Arable crop production

Maps 2.2-3 a to f give a more detailed presentation of the spatial distribution of arable crop production. Cereals production is concentrated in the Donau valley and in the counties of the northern part of the model region, where the fertile areas of Unterland and Gäue allow intensive arable cropping (cf. soil climate index Map 2.2-2 a). Here also the NUTS3 counties with high share of root crops are found. Production of grain maize is found in counties which have the favourite climate of the Rheinebene, where also special crops in form of wine, fruits and vegetables are produced. High concentrations of special crops are found also in the Bodenseekreis and in Unterland/Gäue due to good climate conditions (cf. Map 2.2-1 b and Map 2.2-1 c).

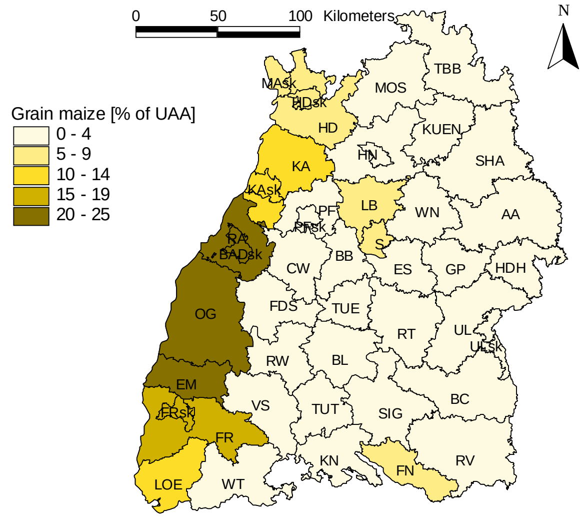
The fodder crop silage maize is dominating and highly concentrated in counties with lower soil climate index (e.g. Biberach) and in counties with intensive arable crop production. Clover shows high shares in the fodder crop in the extensive counties of the Schwarzwald, where soils are less fertile. Slope and climate conditions result here in extensive grassland management.

Map 2.2-3 a: Percentage share of cereals area in REF.



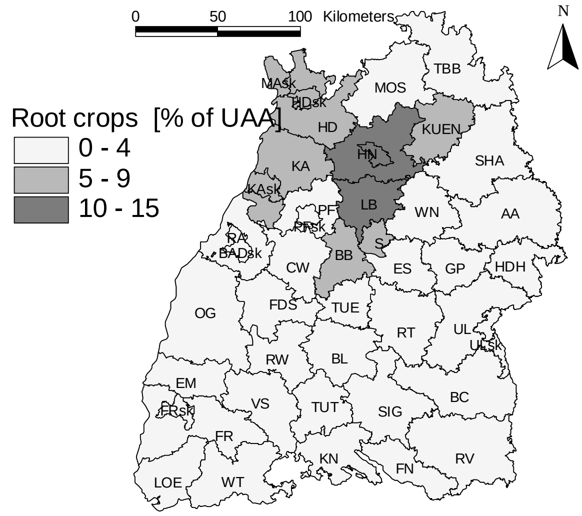
Notes: Unit: % UAA.

Map 2.2-3 b: Percentage share of grain maize area in REF.



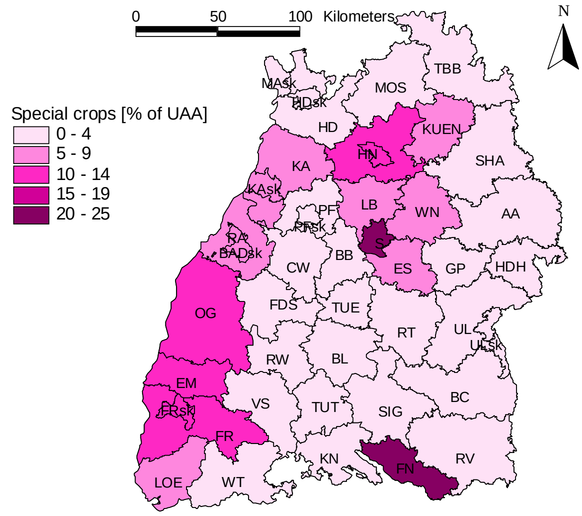
Notes: Unit: % UAA.

Map 2.2-3 c: Percentage share of foot crops area in REF.



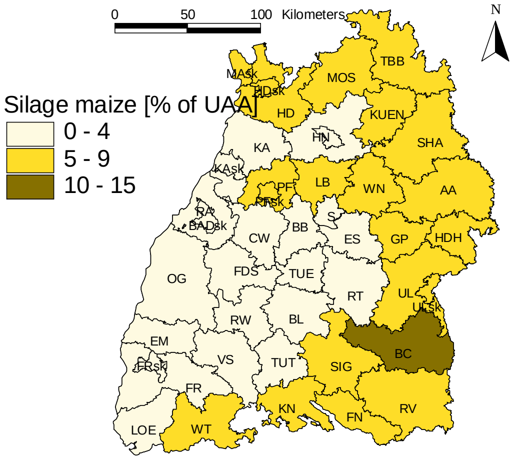
Notes: Unit: % UAA.

Map 2.2-3 d: Percentage share of special crops area in REF.



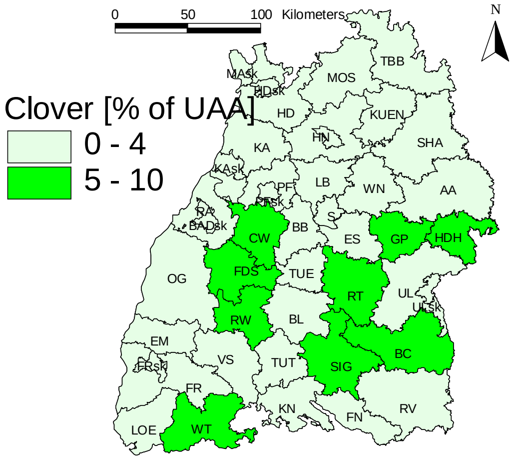
Notes: Unit: % UAA.

Map 2.2-3 e: Percentage share of silage maize area in REF.



Notes: Unit: % UAA.

Map 2.2-3 f: Percentage share of clover area in REF.

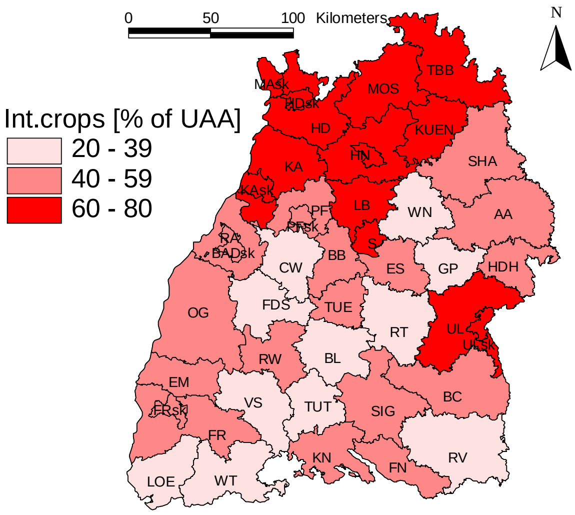


Notes: Unit: % UAA.

Intensity of crop production

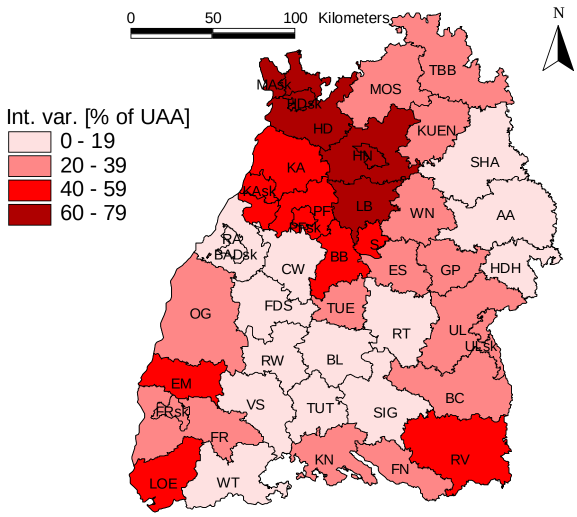
Maps 2.2-4 a and b present the share of intensive crops and intensive crop variants. In NUTS3 counties with intensive arable cropping and special crop production, the share of intensive crops is large. Most of these counties show also high shares of intensive variants. The high share of intensive crop variants in grassland counties with less intensive crop production results form the high share of intensive grassland which is classified as intensive variant (e.g. RV and LOE).

Map 2.2-4 a: Percentage share of intensive crops in REF.



Notes: Unit: % UAA.

Map 2.2-4 b: Percentage share of intensive production variants in REF.



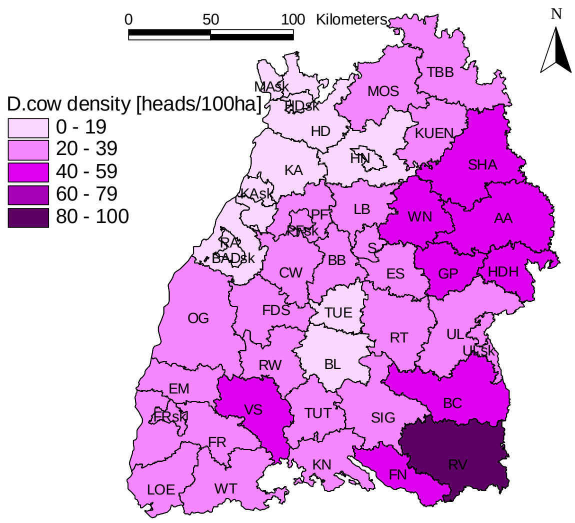
Notes: Unit: % UAA.

Animal production

In Baden-Wuerttemberg, the regionally most relevant animal productions are dairy cow farming, bulls fattening and pigs fattening. Maps 2.2-5 a to c present the animal density of the three livestock classes. The highest concentration of animal production is found in the western half of the study region. Here arable cropping consists of high shares of fodder crops and cereals production which are used for feeding of dairy cows, of fattening bulls and pigs.

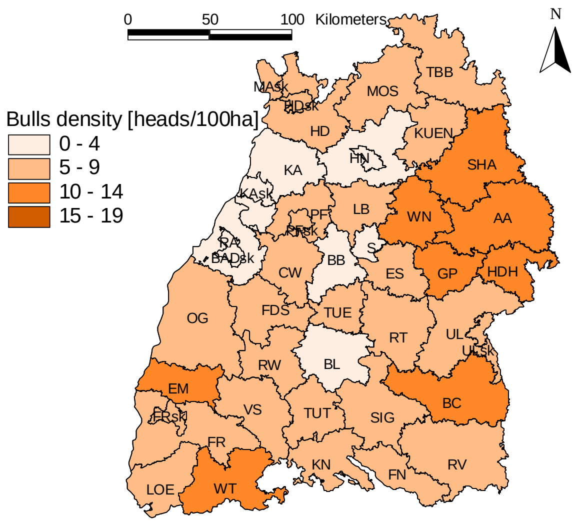
Obviously high concentration of dairy cows and fattening bulls are found in the north eastern counties and south eastern counties with high shares of fodder crop area. Particularly in VGG Allgäu the intensive grassland production favours an intensive dairy stock with more than 80 cows 100 ha^{-1}. In contrast the basis for dairy production in Schwarzwald-Baar-Kreis (VS) is extensive grassland farming. High numbers of bulls are in Biberach (BC) and Waldshut (WT), where the share of fodder crop area is very high. In Emendingen (EM) mainly cereals and intensive grassland supply the fodder demand of fattening bulls. Pig density is highly concentrated in Schwäbisch Schall (SHA), Alb-Donau-Kreis (AL), Heidenheim (HDH), Biberach (BC) and Sigmaringen (SIG), where cereals and fodder crop production is possible.

Map 2.2-5 a: Dairy cows density in REF.



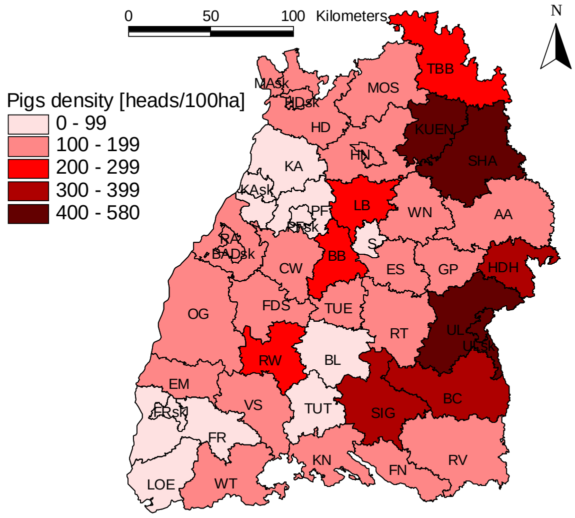
Notes: Unit: heads 100 ha^{-1}.

Map 2.2-5 b: Fattening bulls density in REF.



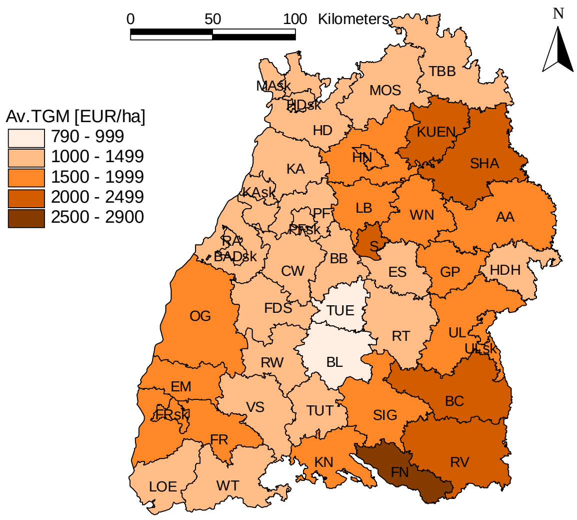
Notes: Unit: heads 100 ha^{-1}.

Map 2.2-5 c: Fattening pigs density in REF.



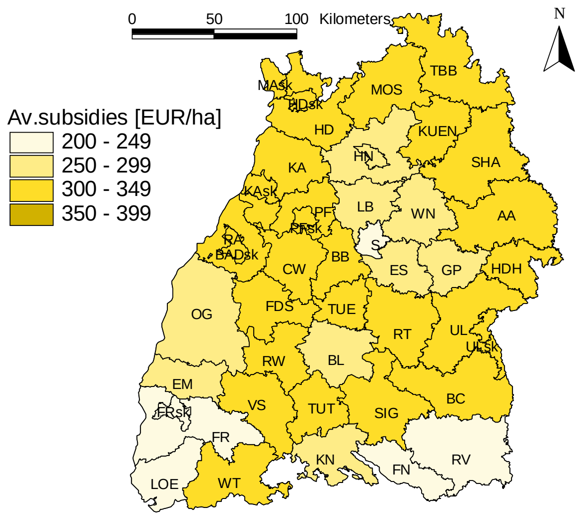
Notes: Unit: heads 100 ha^{-1}.

Map 2.2-6 a: Average TGM in REF.



Notes: Unit: EUR ha^{-1}.

Map 2.2-6 b: Average subsidies volume in REF.



Notes: Unit: EUR ha^{-1}.

Economic indicators

The regional production patterns result in different regional values of economic indicators. In addition, the values of the economic indicators are driven by the market situation and the agricultural policy in the reference year which is the year 2000 under the CAP reform Agenda 2000.[14]

[14] The conditions are 'assumed' because the data described here are calculated by the model, which uses the statistical data of the year 1999 and the political conditions of 2000. Thus, this situation is not an observed situation. A more detailed description on the data of the reference year is given in Subsection 3.1.1.

Average total gross margin and subsidies volume

Map 2.2-6 a presents the average total gross margin as indicator for the agricultural income. NUTS3 districts with high cash crop, fodder crop and animal production show a higher average total gross margin than pure cash crop areas. The counties with the largest income are in areas with high production of fattening pigs and bulls (KUEN, SHA and BC) and with intensive dairy farming (e.g. RV, FR). In counties with high shares of special crops, high share of fruit vine and vegetable show also a high total gross margin (e.g. in KN, S, counties in the VGG Rheinebene). Relative low total gross margins are found in the extensive counties of the Schwäbische Alb Tübingen (TUE) and Zollernalb-Kreis (BL).

Average subsidy volume

Map 2.2-6 b presents the distribution of subsidy volume. NUTS3 counties with high shares of special crop areas and with intensive dairy farming receive relatively small subsidy volumes (e.g. RV, FR) because special crops, dairy cows and grassland farming are not specifically subsidized by policy in the reference year 2000. Due to subsidies for cash crops, silage maize and bulls, higher average subsidies are received in the cash crop areas of VGG Unterland/Gäue.

Environmental indicators

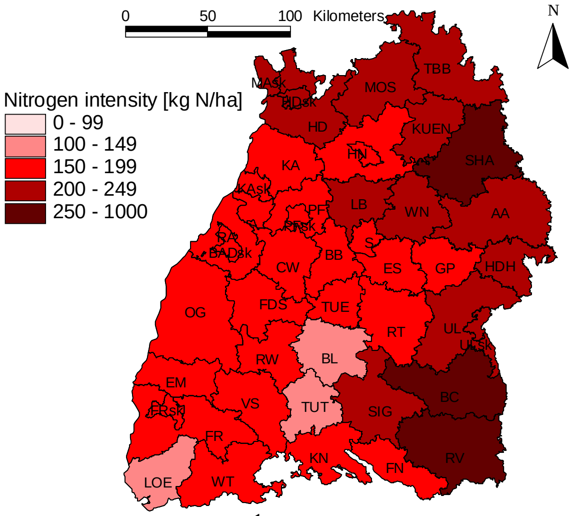
Nitrogen intensity, erosion potential and greenhouse gas emission

Maps 2.2-7 a to d present the indicators for environmental pressure by nitrogen entrance, erosion potential and greenhouse gas (GHG) emissions. Counties with intensive livestock production show high average input of nitrogen. The high amounts of manure result in a high nitrogen entrance (e.g. SHA, RV, BC). Also the intensively cropped arable counties are of high nitrogen intensity, due to high nitrogen demand by crops (e.g. HD, LB).

Erosion potential is very high in intensively cropped counties, where root crops, or vegetable, are of high concentration. The large extension of grain maize production results in the counties of the Rheinebene (e.g. OG, EM) in high erosion potential. In fodder crop counties (e.g. SHA, BC) the high share of silage maize increases the erosion potential.

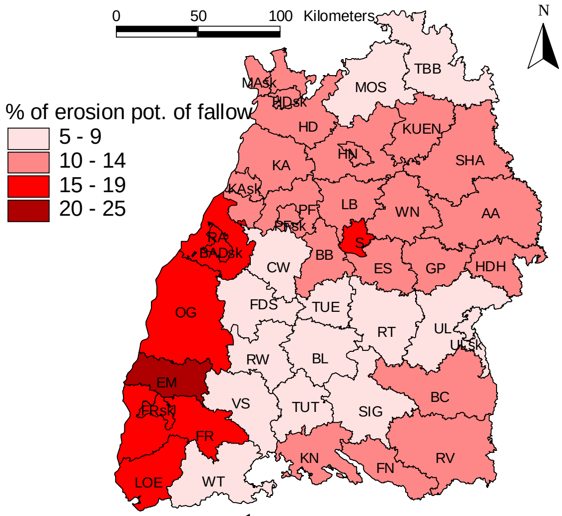
GHG emissions are high in NUTS3 counties with high density of cattle. Cattle as ruminants produce by enteric fermentation large amounts of methane. Additionally, ammonia emissions from manure increase GHG emissions. In counties with intensive arable cropping, the GHG emissions result from the intensive fertilization by mineral and organic fertilizer as well from livestock production which is found there (e.g. bulls fattening).

Map 2.2-7 a: Nitrogen intensity in REF.



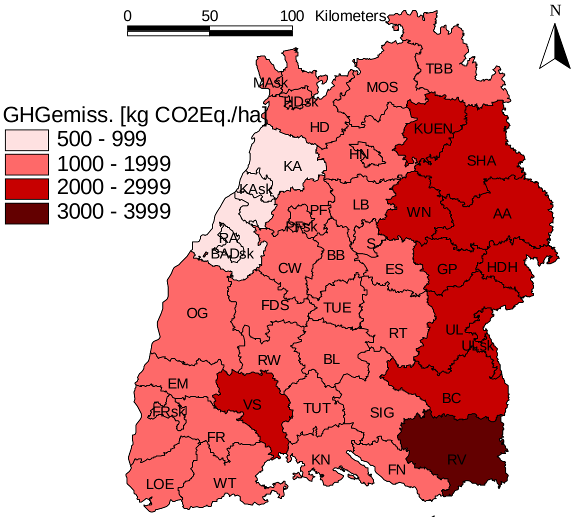
Notes: Unit: kg N ha^{-1}.

Map 2.2-7 b: Erosion potential in REF.



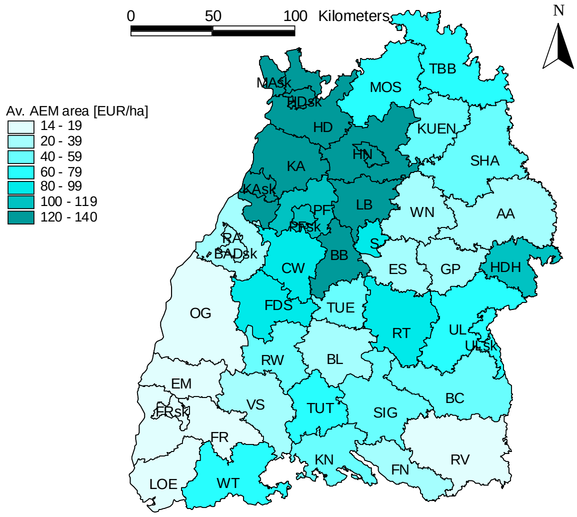
Notes: Unit: kg N ha^{-1}.

Map 2.2-7 c: GHG emission in REF.



Notes: Unit: kg CO_2 equivalent ha^{-1}.

Map 2.2-7 d: Average AEM area in REF.



Notes: Unit: % UAA.

Agri-environmental measures (AEM)

Map 2.2-7 d presents the potential area of AEM of the agri-environmental program MEKA3. In the year 2000 the program MEKA2 was applied. However, in order to make the extension of AEM comparable in the scenarios the potential area of AEM according to MEKA3 has been calculated for the reference year.[15] In intensively arable counties the potential AEM area exceeds 100% because more AEM are possible at the same time on the same hectare of arable land. For example, according to model definition on the same area arable land two different

[15] For more details on how AEM area is calculated in the model see Section 3.5.

AEM can be applied: (1) the four element crop rotation, including (2) green covering measures for set-aside area. Thus, highest shares of potential AEM area are found in counties with high share of arable cropping. Extensive grassland regions show also a high share of potential AEM area, due to extensive cattle and grassland farming.

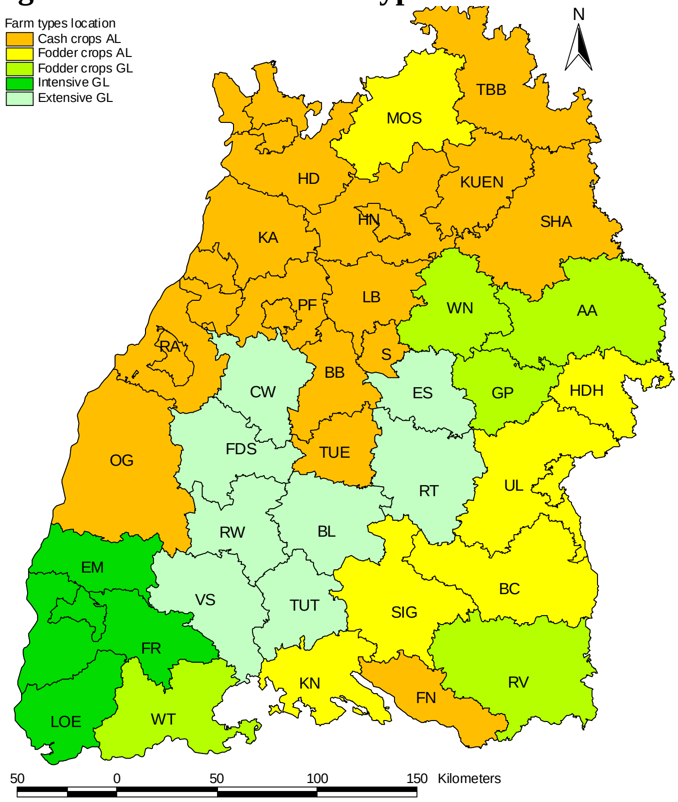
2.2.3 Definition of farm types

Three possibilities to aggregate the smallest regional unit NUTS3 counties to larger units are described in Subsection 2.2.1: NUTS2 districts, the administrative regions at NUTS3 level and Vergleichgebiete. While NUTS2 and NUTS3 regions are defined by the administrative borders they are heterogeneous with respect to agricultural production patterns. The regional unit of Vergleichsgebiete considers comparable agricultural conditions but it does not coincide with the administrative borders of NUTS3 counties (cf. Subsection 2.2.1).

In order to analyse the model results in this study by aggregated units which meet the administrative borders and at the same time represent similar agricultural production the framework of so-called 'farm types' is introduced. In 'farm types' NUTS3 counties of similar land use pattern are grouped. The city counties (except Stuttgart) are aggregated to their next neighbours. Thus the 44 NUTS3 counties are converted into five classes of farm types. Figure 2.2-3 presents the definition of farm types in the model region. For an overview of all NUTS3 counties and the attributed farm types see Appendix 2.2.

The two main classes are arable land counties (AL) with a share of arable land of 60% of UAA and grassland counties (GL) with a share of grassland with more than 40% of UAA. The arable land counties are classified as arable land counties with high share of cash crop (AL-CC) (with a cash crop area of at least 52% of UAA) and as counties with high share of fodder crops (AL-FC), (with a fodder crop area of at least 10% of UAA). The grassland counties are divided into three subclasses: grassland counties with high share of fodder crops (GL-FC) (with less or equal to 10% of UAA fodder crop area), grassland counties with high share of extensive grassland (more than 22% of UAA) and less fodder crop area (less than 10% of UAA), and counties with high share of intensive grassland (with a share of intensive grassland of at least 20% of UAA). This classification into five farm types allows the presentation of the model results by 5 classes, and an interpretation of the results in a more general sense for regions of specific land use. A more detailed characterization of crop and animal production is given in Figure 2.2-3. The map in Figure 2.2-3 illustrates that the farm types show the similar spatial pattern as the maps of the other natural conditions and the soil climate index (cf. Map 2.2-2 d, and Map 2.2-1 a to d). Thus, the farm types represent in a simplified way the regional agricultural production patterns of the study region.

Figure 2.2-3: Selected farm types in Baden-Wuerttemberg.



Definition of Farm types:

AL counties:
>= 60% of UAA arable land
GL counties
>= 40% of UAA grassland

Cash crop counties (AL-CC):
AL counties:
>= 60% of UAA arable land
>= 52% of UAA cash crop area
< 10% of UAA fodder crop area

Fodder crop counties (AL-FC):
AL counties:
>= 60% of UAA arable land
>= 10% of UAA fodder crop area

Fodder crop counties grassland (GL-FC):
GL counties:
>= 40% of UAA grassland
>= 10% of UAA fodder crop area

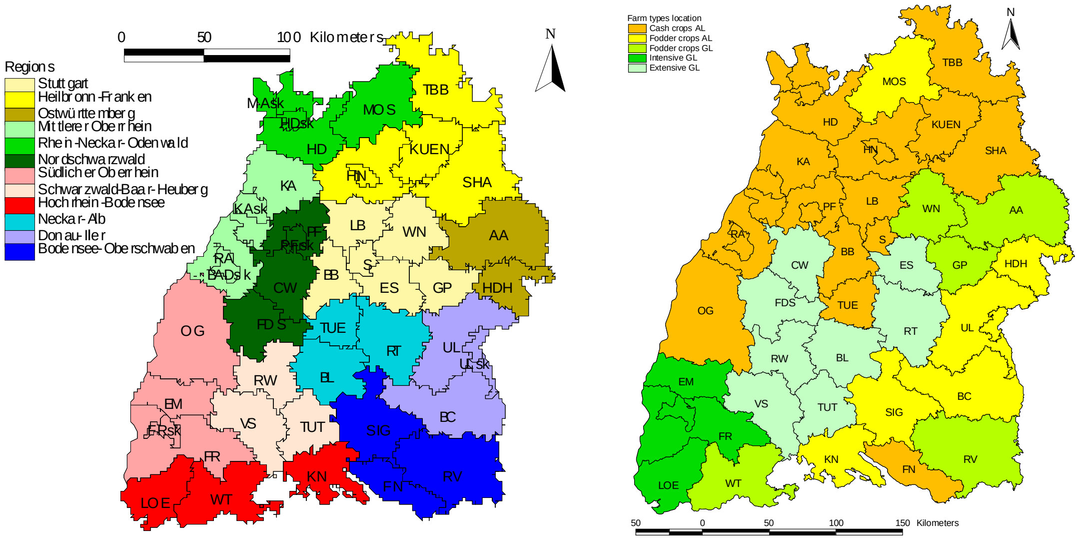
Intensive GL counties (GL-IG):
>= 40% of UAA grassland
>= 20% of UAA intensive grassland
< 10% of UAA fodder crop area

Extensive GL counties (GL-EG)
>= 40% of UAA grassland
>= 22% of UAA extensive grassland
< 10% of UAA fodder crop area

Short characterization of farm types:
AL_CC: crop production: cash crops: cereals, root crops, special crops. Animal production: fattening pigs.
AL_FC and GL_FC: crop production: fodder crops: cereals, silage maize. Animal production: fattening bulls, fattening pigs, dairy production with arable fodder feeding.
GL_IG: crop production: fodder crops: silage maize, clover, intensive grassland farming and extensive grassland farming. Animal production: fattening bulls, dairy cow fed by grassland.
GL_EC: crop production: fodder crops: silage maize, clover, extensive grassland farming. Animal production: dairy cow fed by grassland.

Figure 2.2-4 allows the direct comparison of the map of the administrative regions with the map of the farm types. The comparison shows the heterogeneity of agricultural production within the administrative regions. In some administrative regions different farm types are located, e.g. the administrative region Bodensee-Oberschwaben aggregates FN as an AL-FC, RV as GL-FC and SG as AL-FC. This shows that administrative regions are not appropriate to be used as a framework for regional analysis and thus the advantage of the farm type approach.

Figure 2.2-4: Administrative regions in Baden-Wuerttemberg (left) and NUTS3 counties according to their definition as farm types (right) in Baden-Wuerttemberg.



The regional aggregation to farm types is a suitable aggregation to explain the study results generally. However, it has to be mentioned that in statistical terms this approach might be questionable. To represent the farm type GL-IG only three NUTS3 counties have been selected according to the defined benchmark, while the farm type of AL-CC is relatively overrepresented.

2.2.4 Indicator values in farm types and implications for policy analysis

Table 2.2-2 presents the indicator values in the study region in the reference year. The largest average subsidy volume is found in AL-CC and in AL-FC resulting from cash crop area which is entitled for payments from Pillar 1. In grassland farm types the subsidy volume is lower and the shares of average subsidies are nearly equal for the payments from Pillar 1 and 2. The total gross margin is lowest in GL-EG. Representing the agricultural income here subsidies might have an important meaning to retain agricultural production. The comparison of total gross margin including and excluding subsidies shows that in GL-EG payments of Pillar 1 and 2 contribute with about 26% to the average total gross margin. Thus, a reduction of subsidies could be a sensitive topic in these extensive regions, because it could result in a significant decrease of agricultural income, which then could reduce farming activity. In the other farm types where the share of subsidies on total gross margin is 15% to 20%, a reduction of the payments could be expected to be less problematic.

With respect to food production issues the farm types AL-CC and AL-FC are with about 40% cereals area of UAA the most important ones. Policy scenarios influencing food crop production are important for these regions, which provide important supply for food and fodder cereals. Policy induced changes of intensive and extensive grassland are most important for the farm types GL-FC, GL-IG and GL-EG. The highest animal density of dairy cows, bulls and pigs are found in the fodder crop farm types AL-FC and GL-FC. Therefore, these farm types are important to observe with respect to changes in the environmental indicators nitrogen and GHG emission from livestock. The average input of nitrogen indicates that AL-CC, AL-FC and GL-FC are of highest total nitrogen input. While in AL-CC the largest share of the total nitrogen input is contributed by mineral fertilizer demanded by crop production. In the fodder crop farm type organic nitrogen from intensive livestock contributes a large share of nitrogen. Due to their high cattle density the fodder crop farm types show also the highest GHG emissions. Thus, a policy scenario which influences the animal production can result in changes of environmental pressure in these farm types. The potential AEM area is only in GL-IG relatively small, due to intensive grassland usage and only small share of arable land. In arable farm types the possibility to apply more than one AEM on one hectare UAA increase the potential AEM to more than 100%. In farm types with high shares of extensive grassland (GL-FC, GL-EG) many potential areas for AEM result from AEM applied to extensive grassland. Policy changes can change the extension of potential AEM area which is particularly interesting for farm types with small share of AEM, i.e. GL-IG.

Table 2.2-2: Indicator values in the reference situation.

		AL_CC	AL_FC	GL_FC	GL_IG	GL_EG	Aveverage .of all	All aggre-gated	Minimum	25%quart	50%quart	75%quart	Maximum
Number of counties		14	6	5	3	8	--	36	--	--	--	--	--
SUB vol. Pillar 1 and 2	[EUR ha^{-1}]	294	315	260	249	276	285	288	216	264	289	309	349
SUB vol. Pillar 1	[EUR ha^{-1}]	245	250	159	166	177	212	215	103	167	210	250	316
SUB vol. Pillar 2	[EUR ha^{-1}]	70	91	136	111	134	100	100	36	78	99	128	156
TGM[f] vol.	[EUR ha^{-1}]	1615	1594	1693	1637	1081	1506	1596	761	1164	1400	1854	2821
TGM[f] vol. excl. SUB	[EUR ha^{-1}]	1321	1279	1433	1388	805	1221	1308	497	870	1122	1586	2591
Arable land	[% UAA]	75	68	43	48	47	61	63	28	51	60	73	88
Cash crops	[% UAA]	68	56	32	44	40	53	53	18	41	52	66	83
Fodder crops	[% UAA]	6	11	11	4	6	8	10	2	5	8	10	16
Grassland	[% UAA]	25	33	57	52	53	39	39	12	27	40	50	72
Intensive grassland	[% UAA]	11	8	19	33	47	14	14	4	8	12	15	43
Extensive grassland	[% UAA]	14	24	37	20	40	26	25	3	16	26	36	56
Cereal area	[% UAA]	38	40	23	11	29	32	33	11	24	32	42	55
Maize area	[% UAA]	7	1	1	16	0	4	4	0	0	1	5	25
Fodder crops area	[% UAA]	6	11	11	4	6	8	8	2	5	8	10	16
Others area[h]	[% UAA]	24	15	8	16	11	17	16	5	11	15	21	37
Root crops	[% UAA]	5	1	1	1	1	2	2	0	1	1	2	14
Oilseeds and legumes	[% UAA]	7	9	4	1	6	6	7	0	4	6	9	14
Set-aside	[% UAA]	4	3	2	3	3	3	3	1	2	3	4	8
Converted grassland	[% UAA]	0	0	0	0	0	0	0	0	0	0	0	0
Converted arable land	[% UAA]	0	0	0	0	0	0	0	0	0	0	0	0
Intensive GL	[% UAA]	11	8	19	33	12	14	14	4	8	12	15	43
Extensive GL	[% UAA]	14	24	37	20	42	26	25	3	16	26	36	56
Dariy cows	[heads ha^{-1}]	23	38	56	22	34	32	36	9	20	30	39	89
Bulls	[heads ha^{-1}]	6	10	11	8	7	8	8	3	6	8	9	14
Fattening pigs	[heads ha^{-1}]	209	323	147	99	125	192	225	33	111	148	207	574
Intensive crop area	[heads ha^{-1}]	62	55	32	41	33	49	49	22	35	50	60	80
Intensive variant area	[heads ha^{-1}]	41	21	25	42	17	30	29	7	18	25	40	70
Nitorgen total	[kg ha^{-1}]	198	224	203	161	167	193	203	119	175	191	205	272
Nitorgen organic	[kg ha^{-1}]	67	98	112	72	82	82	90	29	61	83	102	151
Nitorgen demand	[kg ha^{-1}]	133	124	91	96	86	112	114	65	93	116	130	158
Erosion potential	[% of fallow]	9	7	5	8	4	7	7	3	4	7	8	11
GHG emission	[kg ha^{-1}]	1551	2205	2647	1506	1751	1853	2014	975	1483	1791	2052	3655
Potential area of AEM	[% UAA]	121	120	129	86	154	127	122	78	104	119	153	188
Area of intercropping	[% UAA]	18	14	7	5	7	12	12	3	7	11	15	28
Milk yield	[kg cow^{-1}]	4783	5119	5029	4409	4649	4812	- -	3379	4608	4911	5132	5581

Note: -- : no data

2.2.5 Conclusions for the regional analysis framework

The regionally heterogeneous agricultural production in the study region can be explained by the different natural conditions. As the study is done at NUTS3 level, it is important to attribute the NUTS3 counties with the respective natural condition data. However, while data to describe the natural conditions for climate and altitude in the study region are only available for the natural spatial regions Vergleichsgebiete (VG), agricultural production data are given for administrative regions at NUTS3 level. As the natural borders of the VG are not congruent with the administrative borders of NUTS3 counties, information of natural conditions for agricultural production cannot be directly applied to NUTS3 counties. In order to attribute NUTS3 counties with the natural condition data a weighting method is used. A measure for soil productivity is given by the soil climate at NUTS3 level (cf. Subsection 2.2.1).

The status quo of the supply, environmental and economic indicators is analyzed for the NUTS3 counties and describes the study region for the reference year. The analysis of the supply indicator (i.e. the regional agricultural production data for the NUTS3 counties) provides information of the regional distribution of specific production patterns. The soil climate index and the derived natural climate condition data can explain these regional specific production patterns. The status quo of the economic and environmental indicators is described and can be explained by the regional agricultural production patterns and by the agricultural policy in the reference year (cf. Subsection 2.2.2).

The applied method of weighting is an approximation but it can be accepted because (1) the analysis shows that the level of exactness is sufficient to analyse the regional distribution of agricultural production and (2) the soil climate index, which implies the aspects of soils, climate and geography is provided at NUTS3 level, and can be used to explain e.g. the regional agricultural production and the distribution of subsidies and income. Higher exactness might be provided by using data in which the natural areas are attributed to the smallest administrative unit, the NUTS4 municipalities. This would allow for an aggregation of the NUTS4 municipalities to NUTS3 counties and for a more exact weighting. However these data was not available at the time this study was conducted (cf. Subsection 2.2.1 and 2.2.2).

NUTS3 counties with similar agricultural production patterns are aggregated to five different 'farm types'. The comparison with the maps of the natural production conditions illustrates that these farm types represent a simplified regional distribution of agricultural regions. The farm types are used for a more general analysis and they allow transferring the results from farm types to NUTS3 counties with the corresponding production patterns. The comparison with maps at NUTS3 level illustrates that regional aggregation to farm types is a suitable aggregation to explain the study results generally for the reference year. Thus, the derived regional analysis framework can be regarded as suitable for a regional analysis of policy scenarios in the study region in a more condensed and general way than at NUTS3 level (cf. Subsection 2.2.3).

The selection of additional statistical data, which are available for the NUTS3 regions, however not used in this study, might be a useful improvement to create an even more suitable framework to aggregate NUTS3 counties. For the study region data at farm level are available (provided e.g. by MLR 2008A) which describe agricultural production patterns (e.g. average size of farms, number of farms, distribution of average income, distribution of specific farms). It could be a possible alternative approach to use these data in combination with the statistical data at NUTS3 county level to create more representative farm types.

The regional analysis framework differentiates three regional levels which address each different issues of agricultural policy analysis. An analysis for the complete study region of the federal state Baden-Wuerttemberg provides information which might be sufficient and of interest for policy decision making at EU or national level, in order to provide information for policies which are implemented at federal state level. However, such an analysis for the complete study region (i.e. at federal state level) does not reflect the regional heterogeneity of agricultural production within the federal state and therefore is not able to capture differences in policy impacts at the regionally differentiated NUTS3 counties level. The farm type analysis allows for a general representation of counties with similar production patterns and the results of the farm type analysis are representative for the corresponding similar NUTS3 counties. Thus the farm type analysis with 5 farm types allows for an analysis with a better overview than an analysis of more then 30 single NUTS3 counties. However, the changes of indicator values in policy scenarios might be more extreme in the single NUTS3 counties, than in corresponding farm types. For that reason, the additional analysis at NUTS3 level is used in this study to identify policy impacts at regional scale (cf. Subsection 2.2.2 and 2.2.3).

2.3 The agricultural policy model ACRE

Agricultural policy models are used to analyse the impact of policy changes on the agricultural sector. In this study the agricultural policy model ACRE is used for the simulation of policy scenarios. In Subsection 2.3.1 a general framework to characterize agricultural policy models is introduced. Subsection 2.3.2 presents and evaluates the well established agricultural policy model RAUMIS which is comparable to the model ACRE as it features similar characteristics. Subsection 2.3.3 gives a detailed description of the model ACRE, followed by a model validation via ex-post analysis (Subsection 2.3.4) and an analysis of the aggregation error (Subsection 2.3.5). Subsection 2.3.6 concludes and discusses the validation and the features of ACRE in comparison to the RAUMIS model.

2.3.1 Characterization of APM

In a broad sense agricultural policy comprises the context of instruments and policy objectives which influence the actors of the agricultural and food sector (farmers, consumers, government, etc.) and their activities (e.g. production, trade, etc.). Agricultural policy analysis covers on the one hand the systematic collection, explanation and prognosis of economic processes in the agricultural sector as well as the decision processes in agricultural policy making (positive theory). On the other hand agricultural policy analysis can cover also the definition of policy objectives and the investigation of application of policy instruments with respect to the objectives (normative theory) (Henrichsmeyer and Witzke 1994: 15, 16). Agricultural policy analysis investigates the context of agricultural policy with the means of qualitative and quantitative methods. As tools for quantitative analysis agricultural policy models (APM) (or agro-economic models) are used to simulate scenarios of policy, instruments and actors. Garforth and Rehman (2006) classify APM according to four basic characteristics: (1) treatment of the economic equilibrium, (2) modelling technique, (3) aggregation of results, and (4) temporary dimension.[16]

The treatment of the economic equilibrium

The treatment of the economic equilibrium depends on the representation of the economic actors and the sectors in the economic environment. The model can consider the complete economic environment with all sectors and the economic actors firms, government and

[16] For examples of characteristics of applied APM see Appendix 2.3.

households and finds the 'general' economic equilibrium for all the sectors. Within such a Computable General Equilibrium (CGE) model the agricultural sector is often represented as one or few sectors with highly aggregated commodities.
Models which simulate an economic equilibrium, but not for the complete economy, are called Partial Equilibrium (PE) models. Agricultural PE models typically focus to represent the economic actors "producers" and "consumers" for the commodities of the agricultural sector. Most other economic sectors and actors are typically represented exogenously.
Supply models represent only the production side of agricultural markets with the demand side represented by exogenous assumptions (e.g. market prices). The economic equilibrium is assumed to be the optimum of production (profit maximisation) from the supplying actor, which can be a single producer, a group of single producers or an aggregate of a number of producers.
The classical economic actors which are considered in APM are producers and consumers in the agricultural sector. However, the models can consider partially also other actors (e.g. interest groups for environmental protection) or other sectors (e.g. energy market) which interact with the equilibrium for the agricultural sector.

The modelling approach and model structure

The modelling approach describes how the economic assumptions of the models are represented by systems of algebraic equations. Here it can be differentiated between econometric approaches, programming approaches and the agent based approach.
The econometric approach consists on estimating parameters from observed, empirical data. The parameters are used to define the functions (e.g. supply and demand functions) of the models. Thus, statistically observed behaviour is used to define the model and the model reaction. The empirical data describe the behaviour of actors but they do not inform about why the actors behaviour is expressed in certain ways, i.e. the expressions of actors' behaviour are observed and described but not explained.
In contrast to the econometric approach the model developer knows in the programming approach how the actors’ behaviour is built. In the programming approach the economic behaviour of the actors is represented by algebraic functions. The model developer "programmes" the actors' behaviour according to economic principles, i.e. this approach represents how the actor should react to reach an economic optimum.
Models with pure econometric or programming approaches are only used in very special cases, for single studies or as example models. For instance a single farm model can be based

on linear programming and is then an example of a pure programming model. Estimations of regressions to describe farmers' behaviour are examples of pure econometric approaches.

Most of the APM applied for agricultural policy analysis consider econometric as well as programming elements to reflect the behaviour of the economic actors. The share of econometric and programming elements varies within the models. While the reaction of CGE and PE models depends more on the econometric estimation of the functional parameters, the programming approach has a higher relevance for supply models. An example for a combined approach is the Positive Mathematical Programming (PMP) approach. This approach includes the aspect as a programming model of a non-linear algebraic system, and the econometric elements of estimated empirical values to calibrate the functions in the model.

A third modelling approach to mention here is the agent based approach. It is a complex of several approaches for the simulation of autonomous individual behaviour. Agent based models can for example be based on mathematical programming models and elements of evolutionary programming can be added to make the actors able to learn during the simulation of the decision making processes.

The aggregation of results

The aggregation of results can be on farm level, on regional level, at national or at multi-national level. Typically, the results of CGE and PE models are aggregated at national or at multi-national level, while results of supply models represent the regional or farm level. Results of models with higher resolution can be aggregated to a higher level (e.g. from farm scale level to regional level, i.e. bottom-up), while the disaggregation for higher level results (e.g. from national level to regional level, i.e. top-down) requires mechanisms that cope with the regional information of the smaller scaled actors.

The temporary resolution

The temporary resolution describes the shortest simulation period which can be calculated by the model, and the interdependencies within a series of shortest simulation periods. For most of the applied APM models the shortest simulated period is one year. For farm type models or for agent based models also shorter simulation periods might be calculated. For policy analysis usually medium and long term simulations are of interest. When calculating for more than one period the models calculate in a static or in a dynamic way. The calculation from the starting point to the final, the goal period, without considering the time steps in-between, means a comparative static calculation. The results are compared between the status of the base (or reference) year (i.e. the initial year) and the simulation year (i.e. the goal year). Dynamic models consider the in-between steps and their influence on other periods. The dynamic character can be simply oriented in one direction, where the previous period influences the following one. In models with a recursive dynamic a re-coupling from the following period to the previous period is possible.

2.3.2 Description and validation of the regional model RAUMIS

ACRE as a regional supply model is comparable to another supply model which is also applied for agricultural policy analysis: RAUMIS (Regionalisiertes Agrar- und UMweltinformatIonsSystem für die Bundesrepublik Deutschland, engl. regional agricultural- and environmental information system for Germany). Since 1993 the modelling system RAUMIS is implemented by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) and the Johann Heinrich von Thuenen Institut (vTI), Braunschweig. Since 1997 RAUMIS is also implemented by the Research Society for Agricultural Policy and Agricultural Sociology (FAA), Bonn (ILR 2010). RAUMIS is a regional agricultural and environmental information system that is based on a positive mathematical programming approach with a non-linear objective function. The model is used to simulate the impacts of policy measures on agricultural production and environment (Henrichsmeyer et al. 1996; vTI 2008). RAUMIS is part of the vTI model framework[17] which supports policy decision making of the BMELV by prospective quantitative policy scenario analysis. The model framework is used to carry out investigation of developments and policy impacts at different scales: at world and EU markets as well as at sector, regional and farm scale. The scenario simulations are focussed on impacts of trade, agricultural and environmental policy, as well as selected regional policies (Offermann et al. 2010; vTI 2008).

Treatment of the economic equilibrium

RAUMIS represents agricultural production in Germany and is a supply model. Thus, the economic equilibrium is treated by simulating the supply side while the market is represented by exogenous parameters. Agricultural production in RAUMIS is represented for Germany by 31 crop production activities which can be produced by 48 production intensities out of which 2 are intensities for grassland. Animal production is represented by 16 activities fed by 224 feeding alternatives (Cypris 2000: 48, vTI 2008).

[17] For a description of the vTI model frame work see Appendix 2.3.

Modelling technique and model structure

Modelling technique

The model simulating agricultural production in RAUMIS is a non linear programming model based on the PMP approach, which maximizes agricultural total gross margin by optimizing the extension of agricultural production activities. In the following a simple PMP model for crop production is described according to Howitt (1995) by the equations Eq. 2.3.1 to Eq. 2.3.4. These equations describe a PMP model calibrated according to the cost sided approach which explains the decrease in marginal gross margin by the increase of marginal production costs. For details see Howitt (1995), Umstaetter (1999) and Röhm and Dabbert (2003).

Eq. 2.3.1 is the total gross marginal (TGM) function, which is the objective function of the LP model. TGM is maximized by the LP model subject to Eq. 2.3.2 to Eq. 2.3.4. X_i is the optimized extension of the production activities *i*, and $\hat{X}_i$ is the extension of the production activity *i* observed in the calibration situation. The index *i* represents the crop production activity.

max $f(X)$ *where*

$$f(X) = TGM = \sum_i (X_i * [y_i * p_i + SUB_i - c_i]) \qquad \textit{Eq. 2.3.1}$$

with
i: total crop activity i (e.g., wheat, rye or grassland)
X_i *: simulated acreage of crop production activity i [ha]*
$\hat{X}_i$ *: observed acreage of crop production activity (statistic) i [ha]*
y_i *: crop yields of crop activity i [dt ha*$^{-1}$*]*
p_i *: price for crop activity i [EUR dt*$^{-1}$*]*
SUB_i *: subsidies for crop activity i [EUR ha*$^{-1}$*]*
c_i *: variable costs for production of crop activity i [EUR ha*$^{-1}$*]*

subject to

$$\sum_i (X_i) \le \sum_i (\hat{X}_i) \qquad \textit{Eq. 2.3.2}$$

Eq. 2.3.2 limits the resource land and produces the dual value λ_{land}, which is used to calculate the shadow price of the marginal crop activity.

$$X_i \le \hat{X}_i * (1 + \varepsilon_1) \qquad \textit{Eq. 2.3.3}$$

The constraint on the amount of crop activity is represented by Eq. 2.3.3. The total crop activity restriction produces the dual value λ_i.

The perturbation coefficient ε_1, in equation Eq. 2.3.3 is a small positive number. This coefficient enlarges the restrictions of the observed amounts of the activities $\hat{X}_i$ by a small value, which allows the LP model to produce dual values for each crop activity. Nevertheless, the number of constraints exceeds the number of variables by one, which is why one total crop activity constraint produces the dual value of zero. The dual value of zero for the least profitable total crop activity requires a special method of calibration for this so called marginal crop (or marginal activity). The calibration of the marginal activity requires inter alia the shadow price for land λ_{land} (for details cf. Röhm and Dabbert, 2003; Röhm, 2001; Umstätter, 1999).

Eq. 2.3.4 describes the classical version of the objective PMP function for crop activities. For a better overview, yield, price, subsidies, and cost terms in Eq. 2.3.4 are replaced with the equation: $GM_i = y_i * p_i + SUB_i - c_i$

$$TGM = \sum_i X_i \left[X_i * \left(GM_i + \lambda_i * \left(1 - \frac{X_i}{\hat{X}_i} \right) \right) \right] \qquad \textit{Eq. 2.3.4}$$

The positive mathematical programming model in RAUMIS is only a part of the complete information system RAUMIS. The mathematical formulation of the model is described in detail in Cypris (2000).

Model structure

RAUMIS is built in a modular way, which makes it possible to use single modules separately from the others. The modular structure allows for dealing with the huge information requirements and the parallel working with the model by scientists from different institutions. The results of the single modules are exchanged in between the modules and used as input data for other modules (Cypris 2000: 7). RAUMIS consists of four different modules, which are briefly described below.

The module "Grunddatensammlung" (engl. basic data base) contains the original data of the ex-post period. The “Konsistenzrahmen-Modell” (engl. consistency framework model) provides the ranges for the model data used to define the base year. The ranges are derived from data of official statistics. A check of consistency of the base year data is provided for the agricultural production activity extension, input, output and for the monetary data. The "Entscheidungsmodul fuer die Basisjahre" (engl. decision module for the basic years) contains the calibration LP model. It calculates dual values for scarce input factors. The check for deviation between the calculated dual values and statistics provides information about the validity of the model. The calibration parameters for the non linear programming model are calculated here (Cypris 2000: 7, 9).

In submodules the exogenous parameters, calculated by other models, as well as parameters representing progression and trends for the simulation period are implemented. Furthermore, a submodule calculates the optimal special intensity for crop activities, derived from price relations. This submodule determines the extension of production intensities (Cypris 2000: 10).

The "Entscheidungsmodul fuer das Zieljahr" (engl. decision module for the simulation period) contains the non linear programming model which simulates via a process analytical approach the agricultural production in the simulation scenarios. The "Modul zur Loesungsaufbereitung (engl. module for the processing of results) is a framework where the simulation results are discussed with policy decision makers. This module provides the feedback loop from the experts back to the model. Via this module calibration parameters, exogenous and trend parameters can be corrected to aim at simulation results which are consistent with the experts' knowledge (Cypris 2000: 11).

The structure of RAUMIS and the included consistent checks allow for consistency of agricultural and environmental results with official statistics. A coupling with different types of economic and natural models is also possible (Kreins et al. 2010, Offermann et al. 2010, Gömann et al. 2009, vTI 2008).

Aggregation of results

RAUMIS simulates agricultural production at NUTS3 level for Germany. City counties are statistically defined as NUTS3 because of their high population density. Their agricultural area and agricultural production is relatively small. Thus most of the city counties are aggregated with neighboured NUTS3 counties with larger UAA and of higher importance of agricultural production. The simulation results can be analysed for the German 326 single (or aggregated) NUTS3 counties, can be aggregated to 38 administrative districts, different river catchment areas or 76 agricultural regions. The borders of administrative districts and the agricultural regions are congruent with the borders of the Federal States and thus the regional analysis within political borders is possible (Cypris 2000: 31).

Temporary dimension

RAUMIS is a comparative static model, calculating from a base year to a simulation year. Several calibrated base years are available, with 2003 and 2007 being the most recent ones.

The current data base is already updated to the year 2007. The simulation period between base year and simulation year is 10 to 20 years. Thus, with a base year of 2007 the simulation year of 2027 is possible. The shortest simulation period is one year.

Validation of RAUMIS by ex-post analysis

In order to validate the RAUMIS model and to get information on the forecasting quality an ex-post validation has been done (Cypris 2000: 133). Within an ex-post validation results from simulation are compared with statistical data representing the reality. The deviation is a quality measure, indicating how good the model simulation matches reality.[18] Cypris (2000) did the ex-post validation for RAUMIS for two different simulation periods, each of 8 years length. As measure he used the "Mittleren absoluten prozentualen Fehler" (MAPF) (the mean absolute percentage deviation). The MAPF is calculated according to the following equation:

$$MAPF = \sum_i w_i * \left| \frac{X_i - \hat{X}_i}{X_i} \right| * 100 \qquad \textit{Eq. 2.3.5}$$

with
i: production activity
w_i*: weighting of production activity according to the income value*
X_i *: simulated extent of production activity i*
$\hat{X}_i$ *: observed extent of production activity (statistic) i*

Table 2.4-4 presents the MAPF for two simulation periods for the agricultural sector, for single products and for the NUTS3 counties. The MAPF for the sector and the products are evaluated by the benchmarks of prognosis quality which is represented by the forecasting error. According to Hazell and Norton (1986: 271) a forecasting error (here MAPF) between 10% and 13% is 'acceptable', a MAPF of 14% is acceptable but has to be improved, while a MAPF of 15% and greater are not acceptable.
The prognosis quality of RAUMIS for the complete agricultural sector is evaluated with a MAPF of 14% as acceptable however with needs for improvements. The MAPF for the crop production are all not acceptable, while the MAPF for animal production is acceptable (for pork and poultry in the period from 1983 to 1991) and with less then 10% can be even regarded as 'good' (Hazell and Norton 1989: 271). Nevertheless the regional results of the ex-post prognosis of RAUMIS for 1987 and 1991 are not convincing. The mean value of the MAPF of the NUTS3 counties ($MAPF_{county}$) calculated for the simulation periods from 1979

[18] For a more detailed description of the forecasting error see Subsection 2.3.4.

to 1987 and 1983 to 1991are 20% and 24%, while only 50% and 30% respectively of the NUTS3 counties show a $MAPF_{county}$ smaller than 20%.

Thus the forecasting quality at sector scale is acceptable while it is not acceptable at regional NUTS3 level (Cypris 2000: v). However, it is important to keep in mind that RAUMIS is used as a simulation model not as a forecast model. A sensitivity analysis has shown that the model reactions of RAUMIS are plausible with respect to regional adaptation of agricultural production (Cypris 2000: 158). Thus, regional policy impact analysis with RAUMIS is possible also without matching a good forecasting quality. It should be noted that the results of the ex-post validation described by Cypris (2000) are more than 10 years old and no ex-post analysis has been published using the updated version of RAUMIS.

Table 2.3-1: Forecasting errors of crop and animal production in RAUMIS.

		MAPF		**Prognosis quality according to Hazell and Norton, 1986: 271**
		Simulation period		
		from 1979 to 1987	**from 1983 to 1991**	
		%	%	
$MAPF_{sector}$		14	14	acceptable but to be improved
$MAPF_{products}$	Crop production	24	24	not acceptable
	Cash crop production	25	24	not acceptable
	Fodder crop production	21	21	not acceptable
	Animal production	11	10	acceptable
	Cattle and sheep	10	12	acceptable
	Pork and poultry	12	7	acceptable
		% of number of NUTS3 counties		
$MAPF_{county}$	Mean value of all $MAPF_{county}$	20%	24%	not acceptable
	counties with MAPF < 20%	50%	30%	not acceptable

Source: Cypris (2000: 143)

2.3.3 Description of the ACRE model

The APM ACRE has been developed specifically for the region Southern Germany in order to simulate agricultural production at NUTS3 level. The prototype of the model was developed for the Upper Danube catchment area within the framework of GLOWA-Danube by Winter (2005) as the model ACRE-Danube[19]. In several studies ACRE-Danube has been used to analyse the impact of climate and global change scenarios on agricultural production in the Danube catchment area (cf. Wirsig et al. 2007, Henseler et al. 2008, Henseler et al. 2009, Wirsig 2009). Within the project RIVERTWIN-Neckar the model ACRE-Danube was transferred and adapted to the Neckar river basin as ACRE-Neckar, which has been used to analyse the impact of CAP 2003 reform in the Neckar river basin (cf. Henseler et al. 2006, Henseler 2007, Henseler 2008). In the framework of the study at hand ACRE-Neckar was enlarged to the complete federal state Baden-Wuerttemberg (ACRE-Baden-Wuerttemberg, ACRE-BW), and simultaneously extended to the federal state Bavaria (ACRE-Bavaria, ACRE-BY). The complete resulting model covers with Baden-Wuerttemberg and Bavaria the model region of Southern Germany as ACRE-SouthernGermany (ACRE-SG). In the following the term 'ACRE' refers to the complete model (ACRE-SG). In case a specific sub-model is mentioned the regional terms (ACRE-BW, ACRE-BY) are used. If the term 'the model' is used in this study then it refers to the model representing the study region Baden-Wuerttemberg, i.e. ACRE-BW. In this subsection the characteristics of ACRE are described according to the framework introduced in Subsection 2.3.1.

Treatment of the economic equilibrium: supply model and process analytical approach

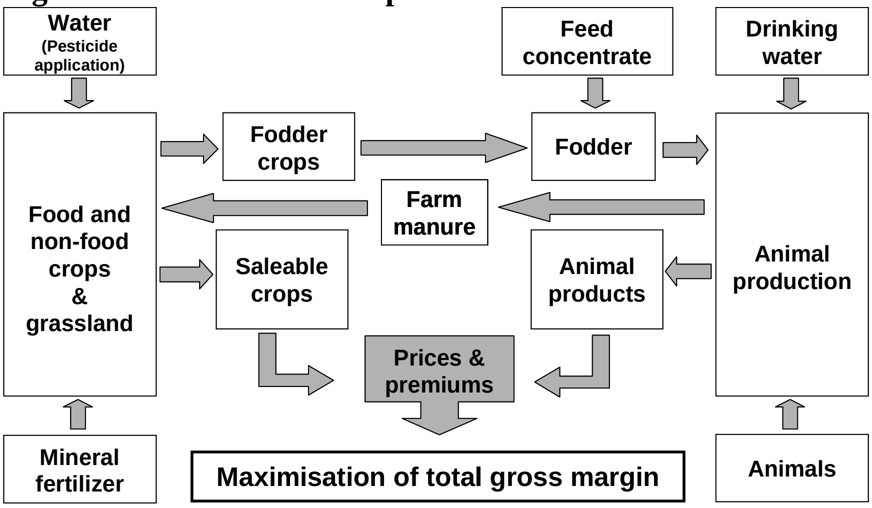
ACRE simulates agricultural production, it is a supply model and the economic environment of the markets is represented by exogenous parameters (e.g. producer prices). ACRE calculates the extension of production activities as well as the total gross margin.

Figure 2.3-1 presents the scheme of the process analytical approach. ACRE simulates agricultural production for the most important processes and interactions in regional agricultural production. On arable land, cash crops or fodder crops for livestock production can be produced. The animals produce manure, which is used as fertilizer in crop production. Mineral fertilizer and feed concentrates are purchased. The applied amount of fertilizer per

[19] Winter (2005) calls the model "Ein Nichtlineares Prozessanalytisches Agrarsektormodell für das Einzugsgebiet der Oberen Donau" (Non-linear processanalytical agricultural sector model for the Upper Danube Catchment). The name ACRE-Danube was given later to the model in order to simplify the naming.

crop is calculated using a linear function that depends on the simulated crop yields (Winter 2005). The prices for crops and animal products, as well as premiums, influence the total gross margin. Trade activities between the counties are not defined.

Figure 2.3-1: Scheme of the production simulated in ACRE.



ACRE represents the production activities in Southern Germany by 24 crop production activities produced in 41 production intensities for agricultural crops and 8 intensities for grassland. Animal production is represented by 16 animal activities with 18 feeding alternatives.

Modelling technique and model structure

Modelling approach

The methodological approach used in ACRE is explained on the example of crop production activities. For detailed information concerning animal production activities, feeding activities or set-aside and corresponding restrictions of these activities, see Röhm (2001) and Winter (2005).

ACRE is based on the calibration method of PMP. A PMP model optimizes agricultural production by maximizing the objective value of a non-linear total gross margin function (Howitt 1995). In comparison to Linear Programming (LP) models, PMP models have the following advantages: they are calibrated by the reference situation and avoid overspecialization; they react continuously to parameter variations and allow a flexible result calculation; and they tend to require fewer data. These features make PMP models particularly suitable for modelling regional agricultural production (Röhm 2001).

A few years ago the PMP method was elaborated to include an additional sub-dimension: the variant activity (Röhm and Dabbert 2003). This variant activity extension differentiates within crop production between two levels of activities with different degrees of substitution characteristics: total crop activities and variant activities. Hence, the extension allows the modelling of different production variant activities of a certain crop, e.g., intensive and extensive production variants. This approach allows the PMP model greater reactivity, since it can react by changing either the extension of variant activities or the total crop activities. This makes the model particularly suitable for simulating such scenarios as measures of agri-environmental programs.

Generally, a PMP model is built in two steps: a LP model, representing the observed statistical situation, calculates dual values which are then used to calibrate the non-linear functions of the PMP model. While in the LP model the number of hectares of crop acreages quite exactly matches statistics, the number of animals simulated by the LP model can deviate from the statistics. The deviation in livestock results from feeding, breeding and herd management activities, which are formulated in the LP model in a representative way but do not represent farming practice completely. Thus, the size of optimal livestock herds simulated by the LP model differs from the numbers of heads given in statistics.

The system of non-linear functions has its optimum at the point where the marginal gross margins are equal. Graphically, this is where the non-linear functions intersect. Thus, the optimum value, or the maximum objective value, is determined by the non-linear function parameters (e.g. the slopes of the non-linear functions). In other words, the LP model produces shadow prices that are used to calculate non-linear function parameters. Dual values ensure the replication of production patterns as simulated by the LP model.

Shadow prices represent the true values of prices for the scarce resource in an observed situation. Thus, a PMP model, calibrated by estimating the non-linear function parameters with shadow prices, essentially depicts an empirically observed value using a non-linear objective function. Fixed restrictions for the activities (which often require exact data that are not available at the regional level) are not needed to determine an optimum. Technological and other limiting constraints, on the other hand, do appear in the PMP model.

A variant activity version of PMP according to Röhm and Dabbert (2003) is described by the series of equations from Eqs. 2.3.6 to 2.3.18. Eq. 2.3.6 is the total gross margin (TGM) function, which is the objective function of the LP model. TGM is maximized by the LP model subject to Eqs. 2.3.7 to 2.3.11. $X_{i,v}$ is the optimized extension of the variant activities i,

v, and $\hat{X}_{i,v}$ is the extension of the variant activity i, v observed in the calibration situation. The index i represents the total crop activity and index v represents the variant activity.

$\max f(X)$

where

$$f(X) = TGM = \sum_i \sum_v (X_{i,v} * [y_{i,v} * p_{i,v} + SUB_{i,v} - c_{i,v}]) \qquad \textit{Eq. 2.3.6}$$

with

i : total crop activity i (e.g., wheat, rye or grassland)

v : crop production variant v (e.g., intensive or extensive production)

i,v : variant activity of crop i and production variant v (e.g., intensive wheat, extensive grassland)

$X_{i,v}$: simulated acreage of variant activity i, v [ha]

$\hat{X}_{i,v}$: observed acreage of variant activity (statistic) i, v [ha]

$y_{i,v}$: crop yields of variant activity i, v [dt ha^{-1}]

$p_{i,v}$: price for variant activity i, v [EUR dt^{-1}]

$SUB_{i,v}$: subsidies for variant activity i, v [EUR ha^{-1}]

$c_{i,v}$: variable costs for production of variant activity i, v [EUR ha^{-1}]

subject to

$$\sum_i \sum_v (X_{i,v}) \le \sum_i \sum_v (\hat{X}_{i,v}) \qquad \textit{Eq. 2.3.7}$$

Eq. 2.3.7 limits the resource land and produces the dual value λ_{land}, which is used to calculate the shadow price of the marginal crop (activity).

$$\sum_v (X_{i,v}) \le \sum_v (\hat{X}_{i,v}) * (1 + \varepsilon_1) \qquad \textit{Eq. 2.3.8}$$

The constraint on the amount of total crop activity is represented by Eq. 2.3.8. The sums of the variant activities ($X_{i,v}$) represent the corresponding total crop (X_i). The total crop activity restriction produces the dual value λ_i.

$$X_{i,v} \le \hat{X}_{i,v} * (1 + \varepsilon_2) \qquad \textit{Eq. 2.3.9}$$

Analogously, the restriction on the amount of the variant activities ($X_{i,v}$) is represented by Eq. 2.3.4, by which the dual value of the variant activities $\lambda_{i,v}$ is produced.

The perturbation coefficients ε_1, ε_2 in Eqs. 2.3.8 and 2.3.9 are small positive numbers. These coefficients enlarge the restrictions of the observed amounts of the activities $\hat{X}_i$ and $\hat{X}_{i,v}$ by a small value, which allows the LP model to produce dual values for each activity. Nevertheless, the number of constraints exceeds the number of variables by one, which is why one total crop activity constraint produces the dual value of zero. The dual value of zero requires a special method of calibration for the least profitable total crop activity, the marginal crop (or marginal activity). The calibration of the marginal crop requires inter alia the shadow price for land λ_{land} (for details see Röhm and Dabbert 2003, Röhm 2001, Umstätter 1999).

To ensure that in the optimization process the substitution between variant activities takes place between variant activities rather than between total crop activities, Eq. 2.3.8 for the total crop activities must be more binding than Eq. 2.3.9 is for the variant activities: The value of ε_2 must be larger than ε_1, resulting in higher dual values for the variant activities. The different shadow prices for total crop activity and variant activity result in differing sizes of non-linear function parameters. This allows the PMP model to optimize by changing the variant activities rather than the total crop activities.

$$\varepsilon_1 < \varepsilon_2 \qquad \textit{Eq. 2.3.10}$$

$$X_{i,v} \geq 0 \qquad \textit{Eq. 2.3.11}$$

Eq. 2.3.13 describes the classical version of the objective PMP function using only total crop activities. Thus, only the total crop activity (X_i, $\hat{X}_i$ and λ_i) appears and the TGM is summed up by index *i*.

Eq. 2.3.14 is the objective PMP function including variant activity extension. It shows the hierarchical relationship between variant activities and total crop activities. The curved brackets include the sums yielded by index *v* and the TGM sum yielded by index *i*. For a better overview, yield, price, subsidies, and cost terms in Eqs. 2.3.13 and 2.3.14 were replaced by the Eq. 2.3.12:

$$GM_{i,v} = y_{i,v} * p_{i,v} + SUB_{i,v} - c_{i,v} \qquad \textit{Eq. 2.3. 12}$$

$$TGM = \sum_i X_{i,v} \left[X_{i,v} * \left(GM_{i,v} + \lambda_i * \left(1 - \frac{X_i}{\hat{X}_i} \right) \right) \right] \qquad \textit{Eq. 2.3.13}$$

$$TGM = \sum_i \left\{ \sum_v \left[GM_{i,v} * X_{i,v} + \lambda_{i,v} * X_{i,v} * \left(1 - \frac{X_{i,v}}{\hat{X}_{i,v}} \right) \right] + \lambda_i * \sum_v X_{i,v} * \left(1 - \frac{\sum_v X_{i,v}}{\sum_v \hat{X}_{i,v}} \right) \right\}$$

Eq. 2.3.14

Eq. 2.3.15 represents the non-linear objective function for crop production as formulated in ACRE. This objective function implies a quadratic cost function. Eqs. 2.3.16 to 2.3.18 represent the parameters for the non-linear functions according to Röhm (2001). In the complete model, further constraints are illustrated in order to consider the requirements of production processes (e.g. animal feeding, herd management, and crop rotation) or market and policy demands (e.g. production quotas or obligatory set-aside). For details, see Röhm (2001) and Winter (2005).

$$TGM = \sum_i \sum_v \left[X_{i,v} * \left(y_{i,v} * p_{i,v} + SUB_{i,v} - c_{i,v} * \left(\delta_{i,v} + \phi_{i,v} * X_{i,v} + \varphi_{i,v} * \sum_v X_{i,v} \right) \right) \right]$$

Eq. 2.3.15

$$\delta_{i,v} = 1 - \frac{\lambda_i + \lambda_{i,v}}{c_{i,v}}$$ *(i.e. the coefficient axis intercept)* *Eq. 2.3.16*

$$\phi_{i,v} = \frac{\lambda_{i,v}}{c_{i,v} * \hat{X}_{i,v}}$$ *(i.e. the slope coefficient of variant activity level)* *Eq. 2.3.17*

$$\varphi_{i,v} = \frac{\lambda_{i,v}}{c_{i,v} * \sum_v \hat{X}_{i,v}}$$ *(i.e. the slope coefficient of total crop activity level)* *Eq. 2.3.18*

The ACRE model is programmed in GAMS. In the current version it is constructed in one single GAMS file including the calibration LP model and the simulation NLP model. An exchange of input and output data to other models is possible via csv-output files.

Aggregation of results

ACRE simulates agricultural production at NUTS3 level for Southern-Germany. As in RAUMIS (cf. Subsection 2.3.2) city counties are statistically defined as NUTS3 because of their high population density. Their agricultural area and agricultural production is relatively small, and therefore all of the city counties except Stuttgart are aggregated with NUTS3 of higher importance for agriculture. The complete ACRE-SG model covers 11 NUTS2 districts and 108 NUTS3 counties including the aggregated city counties. 71 NUTS3 counties and 4 NUTS2 districts are located in Bavaria, 4 NUTS2 districts and 37 NUTS3 counties are located in Baden-Wuerttemberg. The simulation is possible for NUTS3 counties as well as for NUTS2 districts. In contrast to RAUMIS the possibility to calculate results for agricultural regions are restricted in ACRE but it is possible to analyze the results in the context of farm types (cf. Section 2.2).[20]

[20] For details of the aggregation of NUTS3 counties in ACRE-SouthernGermany see Appendix 2.3.

Temporary dimension

ACRE is a comparative static model calculating from a base year to a simulation year. The current base year is 2000, which is based on the production extensions of the year 1999 and price and yield data of 1997, 1998 and 1999. The prototype ACRE-Danube is calibrated to the base year 1995. The shortest simulation period is one year. The simulation period calculated in this study is 15 years with the target year of 2015.

2.3.4 Validation of ACRE by ex-post analysis

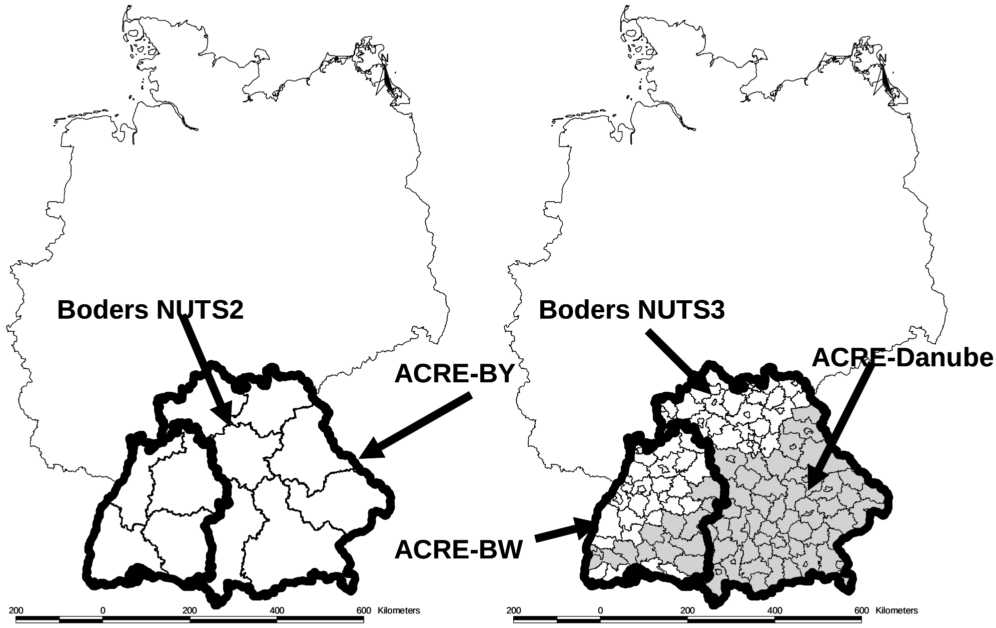
The methodological approach of ACRE is assumed to be a suitable approach to model the supply aspects of the study region at regional level. However, the use of a model for policy analysis requires a validation of the exactness and the correctness of simulated results. The validation of a model is a process, which provides "(1) a numerical report of the model's fidelity to the historical data set; (2) improvements of the model as a consequence of imperfect validation; (3) a qualitative judgment on how reliable the model is for its stated purposes and (4) a conclusion (preferably explicit) for the kinds of uses that it should not be used for" (Hazel and Norton 1986: 269). For the validation, in this study, the simulation results calculated by the model are compared with statistical data of the simulated year. The deviation between the simulated data and the statistical data of production (e.g. crop acreages) quantifies how exact the model simulation represents the statistically observed data.

According to Hazel and Norton (1989: 271) production is "the variable most commonly used in validation tests and for a number of agricultural models there are reported validation results for it." In order to validate ACRE production data of agricultural land use are used. For the ex-post analysis ACRE calculates agricultural production for the year 2007. The simulated crop production data are compared with the latest statistical data which were available for 2007, provided by StaLa (2008) and GENESIS-Online-Statistisches Informationssystem Bayern (2008)[21]. The validation is done with calculation results for ACRE-SourthernGermany (ACRE-SG). The ex-post analysis is provided for the complete model region (ACRE-SG) as well as for the subregions ACRE-BY and ACRE-BW.

Figure 2.3-2 presents the complete model region of Southern Germany with its NUTS2 districts and NUTS3 counties. The grey coloured NUTS3 counties represent the model region of the ACRE-Danube model, for which a model validation has been done by Winter (2005) (cf. Section 2.3.3).

[21] These data bases provide full data surveys of agricultural structural data for the years 1999, 2003 and 2007.

Figure 2.3-2: Maps of Germany and the area covered by ACRE-SouthernGermany and it's sub-models ACRE-BY, ACRE-BW and ACRE-Danube.



Notes:
Map on the left: The borders of Baden-Wuerttemberg and Bavaria and the NUTS2 districts covered by ACRE-SouthernGermany.
Map on the right: The borders of the NUTS3 counties. The grey coloured NUTS3 regions represent the area of the Upper Danube Catchment area.

Simulation at NUTS3 counties and NUTS2 districts level/data analysis

For the ex-post analysis the scenario year 2007 was calculated with ACRE-SG at NUTS2 district and NUTS3 county scale (see Section 2.3.3) by simulating market prices and direct payments according to the situation in 2007. Changes of yield increases, costs and technological parameters are not considered because the impact of these parameters will be overcompensated by the changes of prices and subsidies. The production of energy crops is not simulated. The analysis is done for crop groups which are aggregated specific crops. The aggregation of crops is listed in Table 2.3-2.

Table 2.3-2: Aggregation of crops in crop groups in ACRE-SouthernGermany.

Crop group	Aggregated crops
Cereals	winter wheat, spring wheat
	winter barley, spring barley
	oats, rye, triticale
	corn-cob-mix, grain maize
Fodder crops	clover, silage maize, energy maize
Oilseeds	rapeseed, sunflowers
Root crops	late potatoes, early potatoes, sugar beets
Special crops	hop, fruit
Set-aside	set-aside
Grassland	intensive grassland, extensive grassland

For the analysis of the extension of the crop groups presented in Table 2.3-2 the percentage shares of UAA is used. This relative measure is selected instead of the absolute number of hectares to cope better with (1) possible inconsistencies of the data sets, (2) activities affecting agricultural land use but that are not simulated in ACRE, and (3) validation of the interpreted output data.

(1) Consistency of data sets

The data used for calibration of ACRE were retrieved from the same data source as the statistical data for the comparison, namely StaLa (2008) and GENESIS-Online-Statistisches Informationssystem Bayern (2008). Thus, the consistency of data can be assumed. However, within the eight years between the survey of the calibration data which is 1999 and the compared statistical data in 2007, the surveys of the statistical offices might have be changed, e.g. by adding data of a new crop group as energy maize. The relative value is more robust against such inconsistencies and should reduce sensitivity of the analysis to such inconsistencies.

(2) Changes of data not simulated in ACRE

The differences in land use acreages can either result from inconsistencies and changes in data survey or can result from activities which are not simulated by ACRE (e.g. sealing of arable land by settlement). Since the simulation does not consider such activities this can result in deviations in absolute hectares. By using the percentage share of UAA there is no need for consideration of the area lost by e.g. sealing because the values are related to the UAA.

Table 2.3-3 presents the percentage deviation between statistical data of 1999 and 2007 for the acreages of arable land, grassland and complete UAA. For the complete model region Baden-Wuerttemberg the arable land, grassland and UAA are 4% less in 2007 than in 1999. The deviations in the single NUTS3 counties reach for the most counties between -10% and +10%. In order to correct the differences in land use data the relative measure of UAA is used for the validation.

Table 2.3-3: Percentage deviation between statistical data of 1999 and 2007 for arable land, grassland and UAA in the model regions.

	Percentage deviation 1999 from 2007		
	Arable area	**Grassland**	**UAA**
		%	
Southern Germany	-3.94	-4.08	-3.99
Baden-Wuerttemberg	0.81	-4.07	-1.07
Bavaria	-4.47	-4.08	-4.33

(3) Validation of the interpreted output data

For the analysis and description of ACRE results of crop production the shares of UAA are used. This allows an easier interpretation of changes than absolute hectares or percentage deviations of crop acreages as well as a more flexible way of data exchange with other models (see e.g. Henseler et al. 2008). Thus, the percentage shares of UAA are used to validate ACRE results via ex-post analysis.

According to Hazel and Norton (1989: 271) there is no consensus on the statistic to be used in evaluating the results data and the statistical data, "but in most cases simple measures such as the mean absolute deviation (MAD) or the percentage absolute deviation (PAD) have been used." In this study a weighted absolute deviation (WAD) has been used for the evaluation of the output data with respect to the statistical data.

The weighted absolute deviation (WAD)

Winter (2005) validated ACRE for the year 1999 by using a modified version of the mean absolute deviation (MAD) error. The MAD divides the sum of the absolute percentage deviations (PAD) by the number of 'observations'. Instead of dividing the error by the number of observations Winter (2005) considers the regional relevance of the crops by the regional extension of the simulated crops. He weighted the PAD of each observation by crop specific share of acreage and summed the error within the investigated NUTS3 and NUTS2 regions and the complete model region. This weighted absolute deviation (WAD) was calculated in three different ways:

- WAD_{MR} for the complete model region (i.e. WAD_{BW} for Baden-Wuerttemberg, WAD_{BY} for Bavaria, WAD_{SG} for Southern-Germany)
- WAD_{crop} for the crops (e.g. $WAD_{cereals}$ for the cereals acreage)
- $WAD_{NUTS2,3}$ for the NUTS3 counties or NUTS2 districts (e.g. WAD_{HN} for the WAD in NUTS3 county HN (Heilbronn))

The higher the calculated values of the three weighted deviations are, the larger are the deviation between simulated data and statistical data and the worse is the forecasting quality.

Weighted absolute deviation for the model region WAD_{MR}

The WAD_{MR} sums up all weighted deviations of each item (each crop acreage in each NUTS3 county or NUTS2 district) and thus represents the forecasting quality for the complete model region, respectively the sub regions (SG = Southern Germany, BY = Bavaria, BW = Baden-Wuerttemberg).

According to:

$$WAD_{MR} = \sum_{r,i} \left(\frac{\hat{X}_{r,i}}{UAA_{MR}} * \frac{\left| X_{r,i} - \hat{X}_{r,i} \right|}{\hat{X}_{r,i}} \right) * 100 \qquad \textit{Eq. 2.3.19}$$

with
i: crop production activity
r: region as NUTS3 county or NUTS2 district
$X_{r,i}$ *: simulated acreage of crop production activity i in region r*
$\hat{X}_{r,i}$ *: observed acreage of crop production activity i in region r*
UAA_{MR}: total utilized agricultural area in the model region MR

Weighted absolute deviation for the crop groups (WAD_{crops})

The WAD_{crop} sums up the weighted deviations of the items (crop acreage in county or district) for the crops and thus represents the forecasting of crop area in the model region.

According to:

$$WAD_{crop} = \sum_{r} \left(\frac{\hat{X}_{r,i}}{UAA_{MR}} * \frac{\left| X_{r,i} - \hat{X}_{r,i} \right|}{\hat{X}_{r,i}} \right) * 100 \qquad \textit{Eq. 2.3.20}$$

with
i: crop production activity
r: region as NUTS3 county or NUTS2 district
$X_{r,i}$ *: simulated acreage of crop production activity i in region r*
$\hat{X}_{r,i}$ *: observed acreage of crop production activity i in region r*
UAA_{MR}: total utilized agricultural area in the model region MR

Weighted absolute deviation for the counties ($WAD_{NUTS\ 2,3}$)

In the $WAD_{NUTS2,3}$ the deviations of the item (crop acreage in NUTS3 counties or NUTS2 districts) are weighted by the total area of the regions and sums up the weighted deviations for the districts. Thus, the $WAD_{NUTS2,3}$ represents the forecasting quality for the NUTS3 counties or NUTS2 districts.

According to:

$$WAD_{NUTS2,3} = \sum_{i} \left(\frac{\hat{X}_{r,i}}{UAA_{MR}} * \frac{\left| X_{r,i} - \hat{X}_{r,i} \right|}{\hat{X}_{r,i}} \right) * 100 \qquad \textit{Eq. 2.3.21}$$

with
i: crop production activity
r: region as NUTS3 county or NUTS2 district
$X_{r,i}$ *: simulated acreage of crop production activity i in region r*

$\hat{X}_{r,i}$ *: observed acreage of crop production activity i in region r*
UAA_{MR}*: total utilized agricultural area in the model region MR*

Results of the WAD

Table 2.3-4 presents the calculated WAD_{MR} for the three model regions and the crop groups resulting from ACRE calculations based on NUTS3 and NUTS2 resolution. For BW and SG the NUTS2 resolution provides a better forecasting quality than the resolution of NUTS3 counties. In BY the NUTS3 resolution provides slightly better results. The highest values of the WAD for crop groups are for fodder crops and cereals. With respect to the crops BW provides the smallest values of WAD_{crops}.

Table 2.3-4: Weighted average deviations for the model regions and crops resulting from simulation runs at NUTS3 county level and NUTS2 district level.

		NUTS3			**NUTS2**		
		BW	**BY**	**SG**	**BW**	**BY**	**SG**
WAD_{MR}		7.42	8.49	8.51	7.04	8.56	7.66
WAD_{crops}	Cereals	1.72	2.36	2.44	1.69	2.33	2
	Oilseeds and legumes	1.44	1.43	1.4	1.41	1.19	1.21
	Root crops	0.48	0.5	0.49	0.47	0.46	0.46
	Fodder crops	2.1	2.46	2.46	2.35	3.06	2.6
	Special crops	0.32	0.56	0.48	0.23	0.57	0.47
	Grassland	1.35	1.19	1.24	0.9	0.95	0.92

Table 2.3-5 presents the WAD for the model regions and the NUTS2 districts. The best value is calculated for the model region Baden-Wuerttemberg with a WAD_{MR} of 7.04; the NUTS2 regions in BW are of small values. Karlsruhe shows with a WAD of 8.93 the worst forecast in BW. Most of the NUTS2 districts in BY show higher deviations than NUTS2 districts in BW.

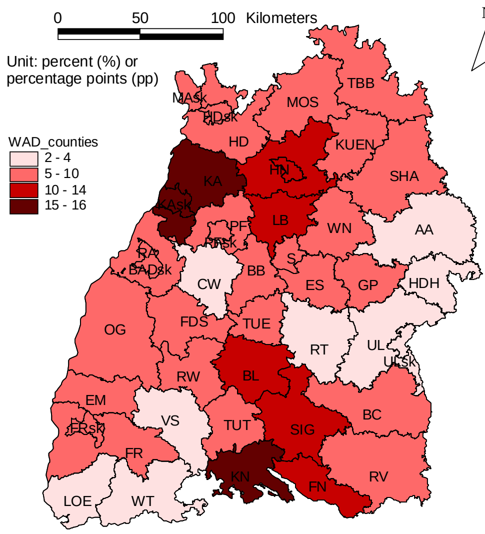
Table 2.3-5: WAD for of the model regions and the NUTS2 districts.

Model regions	$\mathbf{WAD_{MR}}$
Baden-Wuerttemberg	7.04
Bavaria	8.56
Southern Germany	7.66
NUTS2 districts	$\mathbf{WAD_{NUTS2}}$
Stuttgart (BW)	5.83
Karlsruhe (BW)	8.93
Freiburg (BW)	4.73
Tuebingen (BW)	4.66
Oberbayern (BY)	8.99
Niederbayern (BY)	7.12
Oberpfalz (BY)	3.37
Oberfranken (BY)	5.2
Mittelfranken (BY)	8.06
Unterfranken (BY)	17.8
Schwaben (BY)	9.6

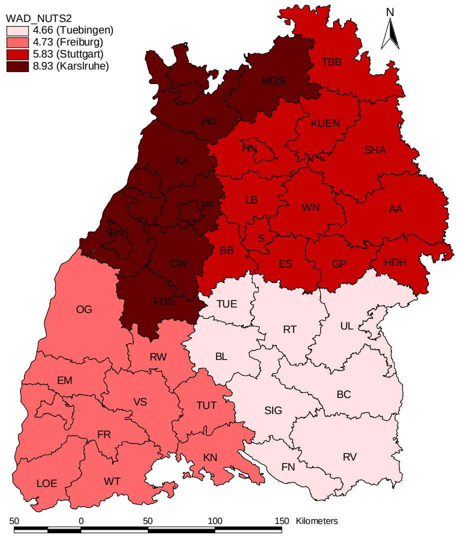
Maps 2.3-1 a and 2.3-1 b present the $WAD_{NUTS2,3}$ at NUTS3 county and NUTS2 district level in Baden-Wuerttemberg. It can be seen that the highest values of WAD are found in intensive arable crop counties KA, HN and LB as well as in some fodder crop counties in the south (SIG, BL). For the NUTS2 districts the WAD_{NUTS2} is best for Tuebingen (4.66) and Freiburg (4.73). Thus, the NUTS2 districts show a better forcasting quality than NUTS3 counties.

Maps 2.3-1 c to h present the WAD_{crops} at NUTS3 county level. The $WAD_{cereals}$ is only for few counties larger than 2, however, these includes counties where cereals production is of high importance (i.e. in MOS, TBB, LB).

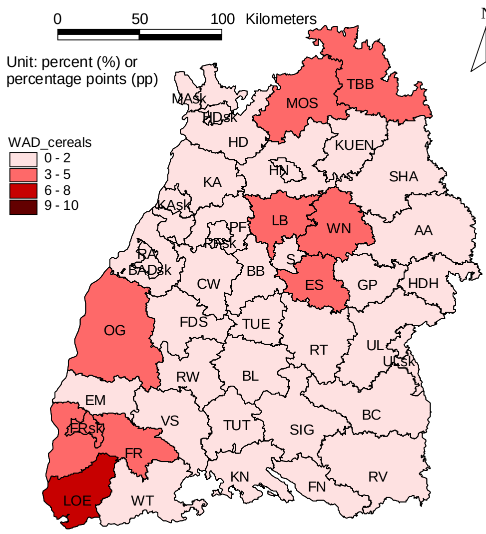
Map 2.3-1 a: WAD_{NUTS3} in Baden-Wuerttemberg.



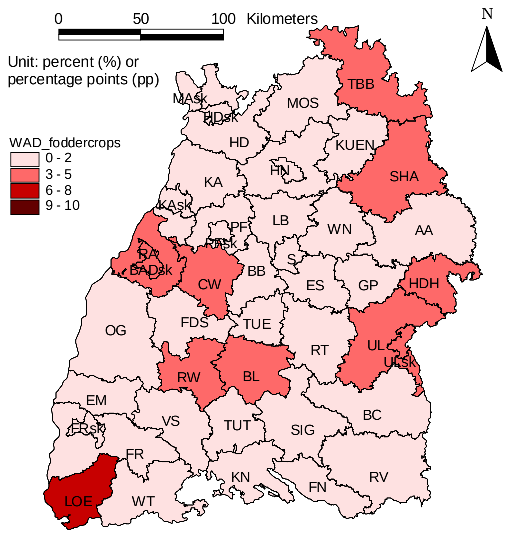
Map 2.3-1 b: WAD_{NUTS2} districts in Baden-Wuerttemberg.



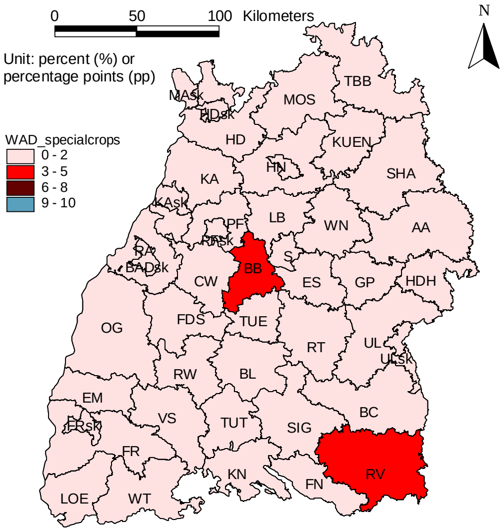
Map 2.3-1 c: $WAD_{cereals}$ in Baden-Wuerttemberg.



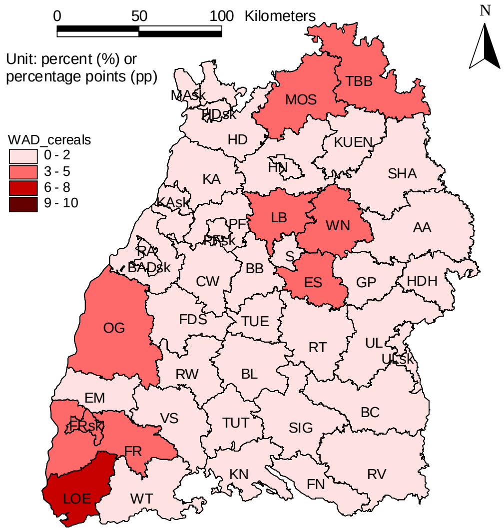
Map 2.3-1 d: $WAD_{fodder\ crops}$ in Baden-Wuerttemberg.



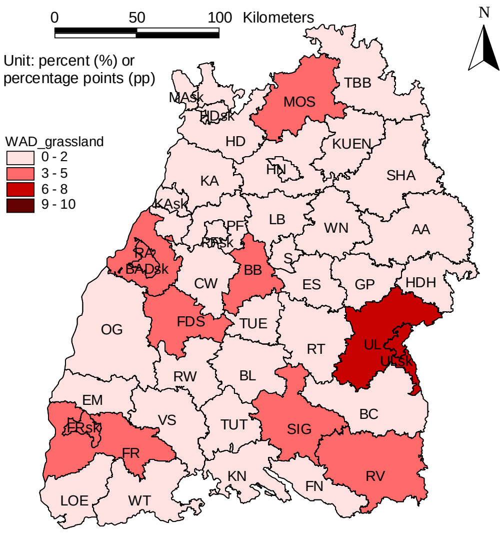
Map 2.3-1 e: WAD$_{special\ crops}$ in Baden-Wuerttemberg.



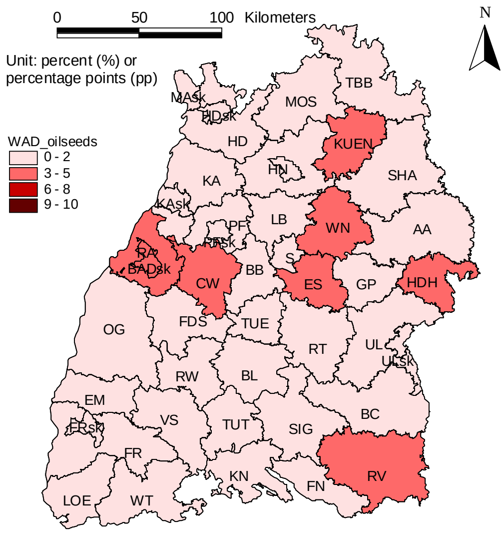
Map 2.3-1 f: WAD$_{fodder\ crops}$ in Baden-Wuerttemberg.



Map 2.3-1 g: WAD$_{grassland}$ in Baden-Wuerttemberg.



Map 2.3-1 h: WAD$_{oilseeds}$ in Baden-Wuerttemberg.



Conclusions for the validation by ex-post analysis

According to Hazel and Norton (1989: 271) and Winter (2005) a WAD of 5% can be valued as exceptionally good, a PAD less than 10% as good and a PAD greater than 15% has to be improved. Thus the majority of the different WAD calculated for the model ACRE suggests a good forecasting quality. The WAD_{MR} for the complete model region of Southern Germany (WAD_{SG} = 8.51) as well as for the sub-regions Bavaria (WAD_{BY} = 8.49) and Baden-Wuerttemberg (WAD_{BW} = 7.42) provide a good forecasting quality, when ACRE simulated at NUTS3 county level. The simulation at NUTS2 level provides a better forecasting quality than the calculations at NUTS3 level for Southern Germany and Baden-Wuerttemberg. For

Bavaria the simulation at NUTS3 level provides even a slightly better forecasting quality. The WAD of the NUTS2 districts are all less than 10 except the NUTS2 district Unterbayern, which's quality should be improved. However, for the study region Baden-Wuerttemberg all NUTS2 districts show a good quality. The WAD_{NUTS3} of most of the NUTS3 regions show also a good forecasting quality.

The analysis of the WAD_{crops} suggest that particularly the oilseeds and fodder crop area is predicted with a lower quality than the other crop groups. A more detailed analysis of the weighted deviations of the crop acreages shows that oilseeds and fodder crops are underestimated in the scenario by ACRE in most of the NUTS3 counties. An explanation of this underestimation could be that rapeseed and silage maize are not representatively modelled as energy crops. Although rapeseed production is associated with a production subsidy of 45 EUR ha^{-1} the production assumptions and prices are derived from rapeseed for food production. This might result in a less competitive activity than a simulated activity for biodiesel rapeseed. In the calculation for the validation silage maize is not considered as energy crop and therefore, the problem is similar to the underestimation of rapeseeds. Thus, ACRE calculates less acreage of rapeseed and silage maize, because both activities are not considered for production of energy. The underestimation of the rapeseed and silage maize result in more area available for production of cereals which can be extended and thus result in an overestimation of cereals. Corrections concerning the activities of renewable crops could therefore result in an improvement of the forecasting quality. For the fodder crops also the ex-post quality of animal livestock is important, however this has not been checked. With respect to both issues, evaluating the prognosis quality of animal production as well as simulation of energy usage of arable crops further modelling work and improvements are necessary.

2.3.5 Validation of ACRE by analysis of the aggregation error

In reality the individual farms are specialized according to their resources and production preferences, which can be quite different due to the heterogonous regional conditions. The aggregation of resources by the 'regional farms' does not match this diversity and allows more flexibility in factor allocation than is given by the single individual farms (Bauer and Kasnakoglu 1990: 276).

The aggregation error results as deviation between simulations at the aggregated regional level and the results for individual farms considering heterogeneities and limited exchange of factor allocation. It is expected that a simulation at a smaller scaled level, which is closer to the farm level like e.g. at NUTS4 (i.e. municipality level) reflect the heterogeneities better than the simulation at NUTS3 level. The aggregation error of the ACRE model has not been investigated yet. Thus, for the study at hand simulation results of different aggregation levels are compared in order to estimate the aggregation error. The basic regional simulation level of ACRE is the NUTS3 level. For a smaller regional level (NUTS4) the available statistical data are not suitable for model building of a PMP model. Due to data censorship the NUTS4 municipalities' data are not reliable and specific crop yields are not surveyed to differentiate the production conditions in NUTS4 municipalities (cf. Section 2.2). To investigate the aggregation error in ACRE the NUTS2 level is used as the highest aggregated regional unit. The data of NUTS2 level are derived by aggregation of the NUTS3 level data. The resulting deviation between NUTS2 and NUTS3 level simulation provides information about the size of the aggregation error.

Analysis of the aggregation error

To analyse the error of aggregation the simulation year 2007 is run for the model region Southern Germany at NUTS3 county level and at NUTS2 district level. The NUTS3 results are aggregated to NUTS2 level and they are compared with the result of the NUTS2 district level calculation. The values in percentage points (for crop group acreages) and percentage (for animal numbers) indicate the range of difference by their size and the tendency of deviation by positive and negative figures. These deviations are used to evaluate the aggregation error.

According to:

$$EAE_{NUTS2} = X_{NUTS2,i} - \sum_{NUTS3} X_{NUTS3,i} \qquad \textit{Eq. 2.3.22}$$

with

EAE_{NUTS2}: Estimation of the agregation error in the NUTS2 district

i: crop production activity

$X_{NUTS2/NUTS3,i}$: simulated acreage of crop production activity i in NUTS2 or NUTS3 region

NUTS2: NUTS2 district

NUTS3: NUTS3 counties contained in the NUTS2 district

Results of calculation of the aggregation error

Generally, the deviations between the simulation results of the NUTS3 and the NUTS2 simulation are with -5pp to +5pp in an acceptable range for most of the crops groups (cf. Table 2.3-6). The largest deviations result in fodder crop production in Freiburg, Oberbayern and Unterfranken. These deviations can be explained partially by deviations in animal production, which are at least in Stuttgart and Karlsruhe, Oberbayern and Unterfranken of consistent direction of development (i.e. higher number of bulls and higher acreage of fodder crops). For Freiburg and Schwaben, the deviations of fodder crop area can not be explained by changes in livestock numbers. Here, more research is necessary to clarify the effects.

Table 2.3-6: Deviations between results simulated at NUTS3 counties aggregated to NUTS2 districts and results simulated for NUTS2 districts.

	Cereals	Oil seeds	Root crops	Special crops	Fodder crops	Grassland	Dairy cows	Bulls	Pigs
	pp of UAA						% of numbers		
Stuttgart	-3	-4	0	0	-4	0	0	-3	0
Karlsruhe	0	0	1	5	1	1	27	19	12
Freiburg	-3	-1	0	0	21	1	0	0	0
Tuebingen	-5	-5	0	0	-3	2	-3	0	0
Oberbayern	4	6	0	0	-14	0	0	-4	-2
Niederbayern	0	-1	0	0	0	0	0	3	-1
Oberpfalz	0	2	0	0	-1	0	0	4	-1
Oberfranken	-1	1	0	0	0	0	0	8	-1
Mittelfranken	-1	2	0	0	0	0	0	2	-5
Unterfranken	1	1	0	0	-7	1	0	-2	-2
Schwaben	1	1	0	0	-3	0	0	15	0

Conclusion from the analysis of the aggregation error

The estimation of the aggregation error shows that the results calculated at NUTS3 level correspond sufficiently exact with the results calculated at NUTS2 level. Higher deviations are found for fodder crops. From this information calculated by bottom-up analysis from NUTS3 to NUTS2 level, it is assumed that the error between NUTS3 and municipality level NUTS4 will be also in an acceptable range to simulate agricultural policy scenarios and show effects on agricultural producers. However, verifying this expectation requires further research.

2.3.6 Discussion of ACRE and its comparison with RAUMIS

This subsection discusses the validation of ACRE and compares the model with the RAUMIS model with respect to model features and in a strengths and weaknesses analysis.

Validation of ACRE

The forecasting error calculated in Subsection 2.3.4 for the complete model region is valued as "good" corresponding to the WAD developed by Winter (2005) and the thresholds published by Hazel and Norton (1986). Winter (2005) validated the regional production model ACRE-Danube by ex-post analysis. ACRE-Danube simulates agricultural production at NUTS3 level for the model region of the upper Danube catchment area (cf. Section 2.3).

The model algorithms and formulations of production processes are used as basis to develop ACRE-SouthernGermany. Winter (2005) calibrated the ACRE-Danube model on the year 1995 and analysed the forecasting error for the 4 years period from 1995 to 1999. The calculated $WAD_{ACRE\text{-}Danube}$ of 7.85 provides a good forecasting quality. The validation results of Winter (2005) have the following implications for the further developed model ACRE-SouthernGermany: (1) the model formulation of the basis have been proved already with a good forecasting quality which is verified by the ex-post analysis of ACRE-SouthernGermany. (2) The ex-post analysis of ACRE-Danube considers a 4 years period where no extreme political changes took place, because both years are under the policy of the MacSharry reform (cf. Section 1.1). However, the ex-post analysis of ACRE-SouthernGermany covers a longer simulation period (from 2000 to 2007) in which a more extreme political change took place (from Agenda 2000 to CAP 2003 reform). Due to the longer simulation period and more extreme policy changes it might be more difficult to forecast the future changes for ACRE-SouthernGermany from 2000 to 2007, than for ACRE-Danube from 1995 to 1999. Nevertheless, resulting in a comparable forecasting quality with a $WAD_{SouthernGermany}$ = 8.51, it can be assumed that the forecasting quality of ACRE-SouthernGermany is at least as good or even better than the forecasting quality of ACRE-Danube. Thus, also for the study region Baden-Wuerrtemberg the model shows a sufficiently good forecasting quality.

The estimation of the aggregation error, described by the deviations between NUTS3 and NUTS2 level, results in an acceptable range for most of the NUTS2 districts. Only the NUTS2 districts Tuebingen and Oberbayern show significantly high deviations in fodder crop area. However, these deviations describe only the error between the smallest regional level NUTS3 and the next larger unit NUTS2. This comparison should reflect the situation as it is suggested according to the definition of the aggregation error. The regional farms at NUTS3 level represent the individual farms with restricted possibilities of allocation of working factors and production restrictions. They are all aggregated in the NUTS2 regions where the factor allocation and production restrictions of the individual regional farms are not considered. This comparison let conclude that the model behavior is similar when calculating at different aggregation level. However, the aggregation error between NUTS3 counties and NUTS4 municipalities or even as individual farms should be more extreme due to higher differences in production restrictions at smaller scaled level.

For the validation of the forecasting quality and the aggregation error the specific crops are grouped in crop groups, which might cover some inaccuracies in simulation of specific crops

(e.g. the error is calculated for the group cereals and not for winter wheat, winter barley, maize etc.). In this study only the crop groups are considered for analysis, thus the validation for crop groups is considered as sufficient. However, a more detailed analysis with respect to the special activities might provide more information. The animal production activities are not considered in the ex-post analysis (cf. Subsection 2.3.3) because of deviations between statistical numbers of livestock and simulated animal numbers.
Overall, the model validation of ACRE shows that the prognosis quality of the model is sufficiently exact to be used as a model for the simulation of agricultural production at regional level in Southern-Germany and in the study region Baden-Wuerttemberg.

Comparison between RAUMIS and ACRE

Summarizing the four modelling characteristics introduced in Subsection 2.3-1 the model ACRE as well as the comparable model RAUMIS can be described as …

… treatment of the economic equilibrium:

- supply model
- process analytical approach
- represented by regional farms

… modelling approach:

- mathematical programming approach

… aggregation of results:

- regional level NUTS3

… temporary dimension:

- simulation period: the shortest simulation period is one year, both models are applied for mid term analysis of about 10 years
- comparative static approach

However, the comparison between the model RAUMIS and ACRE shows several differences between both models (beside the size of the model region). Table 2.3-7 represents the model features of RAUMIS and ACRE. The models are using different versions of PMP, where especially the activity of production intensities is treated differently. While in ACRE the production intensities are calculated via the PMP approach according to production variant activities, in RAUMIS a intensity model calculates intensities. While RAUMIS is build up in a modular structure, ACRE is simply kept in one model file. With respect to the possibilities to simulate activities and policy measures both models are similar equipped. The approaches to aggregate results on natural regions are different and for ACRE just developed for ACRE-

BW. The base year of the current ACRE version is only the year 2000, while RAUMIS is calibrated to several historical reference years reaching from 1997 to 1999. The structure of RAUMIS includes consistency checks of input and output data. The ex-post analysis of the models forecasting quality is not updated. For ACRE no formal consistency checks of data are established, however, an ex-post analysis as well as an analysis of the aggregation error are examined for the study at hand. Significant differences can be detected in aspects of model application and administration. These differences result mainly from the fact that RAUMIS is established in an institutional framework and the maintenance is organised by several staff in permanent positions. This allows keeping of knowledge and continuity in model management. Since RAUMIS is directly used as support tool for policy decision making by decision makers, the number of studies and reports and cooperation partners is significantly higher than for ACRE. ACRE was developed and used in the research framework as decision tool in interdisciplinary projects. Its development is based exclusively on PhD students work and funding is project dependent.

The institutional framework, the direct application as policy decision tool and the time of development (since 1992) result in clear comparative advantages of model development for RAUMIS. Thus, in quantities of output RAUMIS exceeds ACRE significantly. However, with respect to functional possibilities, ACRE is able to compete with RAUMIS at least for the Southern German part, and can be applied as a complementary model to RAUMIS. For example, ACRE could be used as complementary model to RAUMIS in order to analyse especially the impacts of agri-environmental issues.

Table 2.3-7: Comparison of RAUMIS and ACRE.

	RAUMIS	**ACRE**
Economic equilibrium	supply model	supply model
Modelling approach		
- Model category	programming model, optimisation model with non-linear objective function	programming model, optimisation model with non-linear objective function
- Modelling approach	PMP according to Howitt (1995) for the version of Cypris (2000), in the updated version this approach is modified (e.g. considering elasticities from the literature)	PMP developed by Roehm and Dabbert (2003): simulate production activities
	process analytical approach	process analytical approach
	regional farm approach (NUTS3)	regional farm approach (NUTS3 and 2)

	RAUMIS	ACRE
Technical structure		
- Model structure	Modular structure	one model file and input output data
- Programming language	FORTRAN (in the future GAMS)	GAMS
Activities		
- Main production activities	crop and animal production plus intensities	crop and animal production plus intensities
	intensities partially calculated by a special module derived from input output price ratios, partially implemented in calibration, derived from production conditions	intensities implemented in calibration, derived from production conditions
- Other activities	interregional trade and transport activities, quota activities, set-aside activities, herd management	no interregional trade and transport activities, no quota activities (only restrictions), set-aside activities, herd management
- Policies/instruments	direct payments from Pillar 1 and Pillar 2, observation of livestock density, standard management requirements: elements of CCP, agricultural and environmental standards: nutrition according to WFD, erosion, risk potential of pesticides application	direct payments from Pillar 1 and Pillar 2 (partially), no observation of livestock density, standard management requirements: elements of CCP, agricultural and environmental standards: nutrition according to WFD
Aggregation of results		
- Regional coverage	complete Germany	Southern Germany
	Germany 326 NUTS3 regions, 38 administrative districts, several river catchment areas, 76 agricultural regions	4 NUTS2 in BW, 7 NUTS2 in BY 36 NUTS3 in BW 71 NUTS3 in BY farm types (5) analysis
Data		
- Model input data	regional statistics (regularly updated data base), experts' knowledge, national farm accountancy data, trade statistics of the agricultural sector	regional statistics, empirical surveys (for production intensities), not regularly updated data base
- Model output data	economic, production, and environmental indicators	economic, production, and environmental indicators

	RAUMIS	ACRE
Data		
- Temporary dimension	shortest period: 1 year, dynamic: comparative static	shortest period: 1 year, dynamic: comparative static
	base years: 1979, 1983, 1987, 1991, 1995, 1999 2003, 2007	base year: 2000
	projection period: 10-20 years	simulation period calculated: 15 years
Validation		
- Consistency checks	consistency checks with statistics, other APM, experts knowledge of policy decision makers	no consistency check
- Ex-post validations	ex-post analysis from 1979 to 1987 from 1983 to 1991 (no validation with the current version available)	ex-post analysis from 1995 to 1999 (Danube Catchment area) from 2000 to 2007 (for Southern Germany)
		analysis of the error of aggregation
Applications		
- Economic model frameworks	vTI model framework; Institut für Weltwirtschaft Kiel (DART-Model)	no participation in economic model frameworks
- Interdisciplinary model frameworks	GLOWA-Elbe, AGRUM-Weser, REGFLUD, LandCare, NAROLA, AGRUM-NRW	GLOWA-Danubia, RIVERTWIN-Neckar
- Stand alone studies	impact studies of CAP scenarios, renewable energy scenario, different environmental policy scenarios, agri-environmental programs, global change and climate change	impact studies of CAP scenarios, renewable energy scenario, environmental policy scenarios, agri-environmental programs, global change and climate change
Administration/scientific output		
- Development period	since 1992 (first version)	since 2001 (model approach)
- Availability	ownership rights at BMELV, however public use possible	source code at Universitaet Hohenheim, ownership rights unclear, by BMBF project and EU FP 7 framework project
- Maintenance	institutional	project depending

	RAUMIS	ACRE
Administration/scientific output		
- Institutions	BMELV (Federal Ministry of Food, Agriculture and Consumer Protection), Universitaet Bonn, Potsdam Institute for Climate Impact Research (PIK), Center for Environmental research (UFZ), Institut für Gewässerökologie und Binnenfischerei (IGB-Berlin), Forschungszentrum Jülich (FZ-Jülich), Institut für Ostseeforschung, Institut für ökologische Wirtschaftsweisen (just more intensive collaborations are listed here)	Universitaet Hohenheim, Institut for Farm Management
- Scientific publications	>30 doctoral thesis, >40 reports, about 20 scientific papers in ISI	4 doctoral thesis, >10 reports, 2 scientific papers
- Scientific innovations during model history	establishing of interdisciplinary model frameworks	PMP variant activity approach (Roehm and Dabbert 2003)

Strengths and weaknesses analysis of ACRE in comparison to RAUMIS

In order to further investigate the model quality of ACRE and RAUMIS a strengths and weaknesses analysis is conducted which illustrates that both models differ in their strengths, while some of the weaknesses are similar. The weaknesses are resulting partially from the model approach of the "regional farm" and the PMP calibration method. The first results in the aggregation error while the latter requires historical data, which are e.g. not available for energy crop production. With the lack of the land market ACRE results are not necessarily valid for the simulation of abandoning of UAA. The non-linear functions of the model are not flexible enough to keep all area under production, which is why UAA is falling abandoned. A land market function could represent land allocation more realistic by considering a transfer of land between producers. For more details cf. Section 3.2. This shortcoming could be improved by a modification of the model approach or by adding additional modules.

The RAUMIS model shows an insufficient ex-post analysis. However, this ex-post validation has not been done for the updated RAUMIS version. Consistency checks of database and during the calibration process should provide a better ex-post quality in the future for the updated RAUMIS version.

The weaknesses of ACRE result mainly from the institutional context. The development and maintenance of the model depends on funding from research projects. Staff positions working with the model are temporary and do not ensure continuity in model maintenance and development. A model documentation has not been published which makes it difficult to cite a references in scientific publications. Since ACRE has been used mainly as agro-economic model in interdisciplinary modelling frameworks (GLOWA-Danube, RIVERTWIN-Neckar) it has not been implemented into an economic model framework.

An opportunity for the implementation of ACRE in a model framework would be e.g. the use of ACRE as a complementary model with RAUMIS in the vTI modelling framework as a specialized model for the region Southern Germany. ACRE could be focussed then on specific questions like e.g. the impacts of agri-environmental issues. Linkages to other models would be possible. As stand-alone version ACRE could be used as policy decision support tool for the regional decision maker of Bayern and Baden-Wuerttemberg. An installation of the model in such an institutional context could provide continuity in maintenance and development. However, establishing such a cooperation needs promotion of the model for the potential stakeholders to get their interest.

A strength of ACRE is the coverage of two administrative regions which are similar with regard to agricultural and agri-environmental questions. ACRE is in a development status of relative low complexity. Thus, further development of the model is possible with relative low entrance costs. Since the model is based on a PMP calibration approach which allows for simulation of agri-environmental programs, ACRE could be used as a specialized model to investigate agri-environmental policy question. The ex-post analysis proofed a good forecasting quality even for a forecasting period with relative strong policy reforms. Therefore ACRE is an operational APM for Southern-Germany and for Baden-Wuerttemberg and is suitable to be used for the policy scenarios calculated in this study.

Table 2.3-8 summarizes the strengths and weaknesses analysis for RAUMIS and ACRE.

Table 2.3-8: Strengths and weaknesses analysis for RAUMIS and ACRE.

	RAUMIS	ACRE
Strengths		
Specific features making the model exceptional in comparison to the other APM	coverage of total Germany	coverage of the two comparable federal states BW and BY, regionally specified
	regular updating of calibration	variant activities are based on production conditions
	consistency checks with statistics	validation by ex-post analysis provided a good forecasting quality
	feedback loop with experts' knowledge to monitor results	
	modular structure	degree of complexity of the model is relatively low, one GAMS file
	representation of trade activities between regions for milk quotas and set-aside obligations, and organic fertilizer	
Opportunity for further application and development	disaggregation according to production locations	application for regional specific questions addressed to local authorities
	trade between regions for trade of e.g. breeding animals or fodder	focus of model development to specific issues filling gaps of other models (e.g. for environmental programs)
	consideration of more non-linear functions than already represented in the regional farm	work in cooperation with RAUMIS as satellite model for Southern Germany
		coupling to other economic models (e.g. market models like CAPRI)
Weaknesses		
Caveats, which exists but can be solved	results of the ex-post validation 'weak', however no ex-post validation with the updated RAUMIS version, simulation model	maintenance is project depending, there is no institutional funding
		data base of production formulation is not updated
		base year is 2000, should be updated
		no implementation in economic model framework

	RAUMIS	ACRE
Shortcomings which question the reliability of the model results, and which - cannot be changed - can just be changed with further essential model development - for which other model are better to be applied		no land market is modelled; activity of abandoning of UAA is not modelled in a reliable way
	aggregation error	aggregation error
	calibration of energy crops is based on derivation from other crops	calibration of energy crops is based on derivation from other crops
		there is no complete model documentation available

3 Scenario simulations

In the following sections different policy scenarios are conducted. The scenarios are defined according to recent discussions on the future development of the CAP. Section 3.1 presents the reference year representing the reform of Agenda 2000 and the baseline scenario in which the CAP 2003 reform is simulated. The baseline scenario is then used as the reference to compare the results of other policy scenarios.[22] In Section 3.2 the impacts due to reduction of payments from Pillar 1 and the expansion of payments from Pillar 2 are examined. Section 3.3 presents the impact of energy crop production. A scenario with a restriction of nitrogen input for agricultural production is analysed in Section 3.4 and Section 3.5 presents a scenario assuming mandatory AEM. Section 3.6 examines the results of scenarios in which all the policy instruments from Section 3.2 to 3.5 are combined. Table 3.0-1 presents an overview of all scenarios simulated and analyzed in this study.

Table 3.0-1: Overview of the investigated scenarios.

Scenarios	Name	Assumption of CAP reform / policy instrument or market situation
Reference year	REF	Agenda 2000
Baseline scenario	CAP2003	CAP 2003 reform
Subsidy reduction scenarios	SUBred60%	reduction of direct payments from Pillar 1 by 60%
	SUBshift70%	shifting of 70% of direct payments from Pillar 1 to Pillar 2
Energy crop scenarios	EmaizeWW	energy maize production of high competition with food production
	EmaizeSM	energy maize production of low competition with food production
Nitrogen reduction scenarios	N170kg	restriction of input of organic nitrogen intensity to 170 kg organic N per ha
	Nred90%	restriction of input of nitrogen to 90% of the reference year
Mandatory AEM scenario	Mandatory AEM	application of AEM are mandatory
Combined scenarios	INT	situation of intensive agricultural production, combination of assumptions of scenarios SUBred60%, EmaizeWW, Nred170kg
	EXT	situation of extensive agricultural production, combination of assumptions of scenarios SUBshift70%, EmaizeSM, Nred90%

3.1 Reference year and baseline scenario

The reference year is a modelled situation, simulating the year 2000 as if the policy reform Agenda 2000 would have been already fully implemented and reproduces the statistical data of the year 1999, on which ACRE is calibrated. While the reference year represents a scenario which is similar to a historical situation, the baseline and the other policy scenarios are simulated according to the assumptions of the expected policy conditions in year 2015. The baseline scenario represents a simulated projection of the future development of the

[22] For detailed presentation of the scenario results see tables in Appendix 3.1.

agricultural sector in the study region under the policy of the CAP 2003 reform (cf. Section 1.2). This chapter describes the assumptions and modelling of the reference year (Subsection 3.1.1) and of the baseline scenario (Subsection 3.1.2). The results of the baseline scenario are analysed according to NUTS3 counties (Subsection 3.1.3) and farm types (Subsection 3.1.4) and the baseline scenario is discussed in Subsection 3.1.5.

3.1.1 Scenario assumptions and modelling of the reference year

This subsection describes the assumptions of the reference year (REF) with respect to policy instruments, agricultural markets, regional production patterns and conditions.

CAP payments from Pillar 1 and Pillar 2

The reference year is based on Agenda 2000 policy which differentiates the CAP payments into payments from Pillar 1 (market and price policy) and payments from Pillar 2 (rural development policy) (cf. Section 1.2).

Direct payments from Pillar 1

In REF the payments from Pillar 1 are linked to fixed areas or yields or to the number of animals and are referred to as 'coupled direct payments' (cf. Section 1.2). This kind of coupling results in different payments for crop and animal production; e.g. cereals area is entitled for direct payments of 302 EUR ha^{-1}, while the payments for maize area are 427 EUR ha^{-1}. For bulls direct payments are 160 EUR $head^{-1}$ but there are no payments for dairy cows and pigs. It is expected that the different payments from Pillar 1 result in production decisions that are not purely market oriented, i.e. farmers may opt to produce products with higher direct payments instead of products with higher market demand (cf. Section 1.2 and Table 3.1-1).

Payments from Pillar 2

The payments from Pillar 2 in REF are derived according to the "Massnahmen und Entwicklungsplan 1" (MEPL1)[23] of Baden-Wuerttemberg, including the agri-environmental program "Marktentlastungs- und Kulturlandschaftsausgleich 2" (MEKA2). In MEKA2 the payments are defined for different management intensities of grassland and intercropping on arable land. Intensive grassland is entitled for 90 EUR ha^{-1}, extensive grassland is entitled for 130 EUR ha^{-1} and intercropping is entitled for 110 EUR ha^{-1}. Compensatory allowances are

[23] MEPL1 was applied in Baden-Wuerttemberg from 2000 to 2006.

assumed for arable production of low profit cash crops (e.g. barley, clover) and grassland farming. In REF the size of the compensatory allowances are determined by the yield measure index "Landwirtschaftliche Vergleichszahl" (LVZ) and the regional soil climate index (cf. Section 2.2; see also Table 3.1-2).

Production quotas and market restrictions

In REF the mandatory set-aside rate is simulated to be obligatory for 10% of cash crop area (cereals, grain maize and oilseeds, excluding root crops and special crops). The extent of sugar and milk production is restricted by the production quota as specified in REF (i.e. limited hectares for sugar beet and limited stable places for dairy cows).

Apart from specific policy instruments the market (supply and demand) itself limits production of several commodities. On the one hand a limited demand by consumers restricts the production for commodities that are not subsidized (e.g. potatoes and vegetables). On the other hand the limited availability of the production factor 'suitable area' restricts production. Commodities for which these restrictions apply are crops with special production requirements of land (e.g. limited areas with fruit, vineyards or soil quality for sugar beet and vegetables). This restriction of production activities holds also for the baseline and for the simulated policy scenarios. Production quota and demand restrictions are modelled as model constraints based on the extent in REF.

Prices, costs and yields

The prices and costs considered in this study are all nominal. Representative producer prices are calculated for the reference year 2000 as the three-year average of the regional prices of the years 1997, 1998 and 1999. The average of three years smoothes the deviation of prices caused by temporary irregularities (e.g. due to yearly price and yield variations). The variable costs of production are derived according to Winter (2005) from the KTBL data collection of the years 1995 to 1999[24]. Equivalently to the prices, the crop yields are derived as an average of the regional crop yields of the years 1997-1999. The reference dairy yields are the yields of 1999.

[24] For this study it was actually foreseen to update these data to the year 1999/2000. However, as only small influences were expected to result from updated data an update was finally not necessary.

Extent of crop production and livestock

The extent of crop and animal production is derived from the regional statistical data of the year 1999, which represents the closest available production data to the year 2000. [25] Animal production is restricted by the number of stable places, suggesting that the scenario results will show a decreasing tendency in animal production and that the simulation time of 15 years is too short to assume investments in stable places (cf. Winter 2005: 117).

[25] An inconsistency might occur by using production data of 1999, where the policy of the MacSharry reform was still valid. Thus, the reference year 2000 represents a scenario that combines the statistical data of the year 1999 while assuming the policy of Agenda 2000.

Table 3.1-1: Production conditions in reference year 2000.

Commodities	Prices in reference year	Pillar 1 payments	Average variable costs	Average variable yields	Market restrictions/production quotas
	EUR dt^{-1}	EUR ha^{-1}		dt ha^{-1}	
Crop products					
Winter wheat	11.6	302	662	68	
Spring wheat	12.2	302	489	58	
Winter barley	11.3	302	606	62	
Spring barley	13.6	302	472	51	
Rye	10.4	302	566	56	
Oats	10.4	302	461	51	
Triticale	n.d.	302	n.d.	n.d.	
Grain maize	12.6	427	772	91	
Rapeseed	25.0	499	724	33	
Legumes	12.0	384	385	37	
Sunflowers	22.4	499	691	30	
Potatoes	7.8	n.d.	1756	308	reference acreage
Sugar beet	5.2	n.d.	1011	576	reference acreage
Vegetable	6.4	n.d.	974	637	reference acreage
Fruit	40.1	n.d.	3690	300	reference acreage
Hop	n.d.	n.d.	n.d.	n.d.	
Vine	165.6	n.d.	13746	121	reference acreage
Landuse					
Set aside		310	213		10% of cash crop area
Intensive grassland		n.d.	222	72	
Extensive grassland		n.d.	79	28	
	EUR unit^{-1}	EUR head^{-1}		Unit head^{-1}	
Animal products					
Milk [e]	34		n.d.	4695	reference stable places
Beef (from bulls) [f]	365	160	n.d.		reference stable places
Beef (from calve) [f]	321		n.d.		reference stable places
Beef (from cow) [f]	110	163	n.d.		reference stable places
Breeding heifers [f]	1138		n.d.		reference stable places
Young bulls [g]	374		n.d.		reference stable places
Young heifer [g]	250		n.d.		reference stable places
Male calves [g]	140		n.d.		reference stable places
Female calves [g]	89		n.d.		reference stable places
Pork [f]	132		n.d.		reference stable places
Piglets [g]	35		n.d.		reference stable places
Lambs [g]	66	23	n.d.		reference stable places
Poultry [f]	125		n.d.		reference stable places
Eggs [h]	10		n.d.		reference stable places
Ride horses [g]	600		n.d.		reference stable places

Notes: a) Historical prices for Germany in the year 2007. Source: vTI (2007). b) Price projections. Source: OECD-FAO 2007, OECD-FAO 2003. c) Price projections: Binfield (2007). d) n.d.: no data e) Notes: Unit: 100 kg. f) Notes: Unit: 100 kg slaughter weight. g) Notes: Unit: animal. h) Notes: Unit: 100 eggs. n.d. no data given here

Source: ACRE-model-code

Table 3.1-2: Payments from Pillar 2 in reference year.

Compensatory allowance		
LVZ [a]	**Fodder area [b]** **EUR ha^{-1}**	**Less profit cash crops area [c]** **EUR ha^{-1}**
<15	178	89
15	170	85
16	162	81
17	154	77
18	146	73
19	138	69
20	130	65
21	122	61
22	114	57
23	106	53
24	98	49
25	90	45
26	82	41
27	74	37
28	66	33
29	58	29
>30	50	25

Agro environmental measures	**MEKA2** **EUR ha^{-1}**
Intensive grassland	90
Extensive grassland	130
Intercropping	110

a) Derived from the soil climate index by devision by 1.5 according to Winter (2005). b) Clover and grassland. c) Barley, oats, rye, sunflowers, triticale, legumes.

Source: MLR (2005A), MRL (2007A)

3.1.2 Scenario assumptions and modelling of the baseline scenario

The baseline scenario (CAP2003) represents a simulated projection of the future development of the agricultural production in the study region. The scenario year is the year 2015 and it is simulated that the policy measures of the CAP 2003 reform are continued up to this scenario year. The scenario assumptions of the baseline scenario are the starting point for the other policy scenarios which represent simulated projections of future developments under the assumption of additional policy instruments.

On the one hand the results of the baseline scenario are used to describe the expected consequences of a continuance of CAP 2003 reform measures to 2015, and therefore results of the baseline scenario are compared with results of the reference year. On the other hand the baseline scenario results are later on compared with the results of the other policy scenarios in order to describe the impact of the simulated additional policy instruments.

CAP payments from Pillar 1 and Pillar 2

In the baseline scenario CAP payments are simulated according to the CAP 2003 reform which includes fully decoupled payments form Pillar 1 associated with cross compliance and payments from Pillar 2.

Direct payments from Pillar 1

In the final stage of the CAP reform 2003 the direct payments from Pillar 1 are assumed to be fully decoupled from production which means they are not related to a specific type of product or production. The payments are linked to entitlements based on historical subsidy receipts and are supposed to ensure a basic income support while at the same time giving farmers the flexibility to produce more market oriented (EC 2009A).

In the study region Baden-Wuerttemberg the direct payments from Pillar 1 are of a harmonized size of 302 EUR ha^{-1} for agricultural area (arable and grassland) used for agricultural production. For energy crops (energy maize and oilseeds) a special payment of 45 EUR ha^{-1} is received[26]. For animals, no specific direct payments are paid. The payments from Pillar 1 as they are simulated in the baseline scenario are presented in Table 3.1-3.

The CAP 2003 reform also defined cross compliance regulations to be complied with by the farmers as precondition to receive the direct payments from Pillar 1. Out of the cross compliance regulations the following three main obligations are simulated in the baseline scenario: (1) the standard of good agricultural practice is represented by the definition of the fertilization activity according to the "Nitrate Directive" (Directive 91/676/EWG); (2) keeping agricultural area in good agricultural and environmental conditions (GAEC) is represented by the obligation of covering at least 40% of arable area to avoid soil erosion and (3) the retaining of permanent pasture is simulated by allowing only a maximum of 10% of grassland to be converted into arable land.

[26] The special payment for energy crops were abolished in 2008 after the CAP Health Check, however assumed to be still paid in this study.

Table 3.1-3: Direct payments from Pillar 1 in the reference year in 2000, according to the CAP 2003 reform and as simulated in the baseline scenario (CAP2003).

	Reference	Final state of CAP reform 2003		Baseline scenario	
	Coupled payments	Decoupled payments	Additional aids	Decoupled payments	Additional aids
Crop production			EUR ha^{-1}		
Cereals	302	302	0	302	0
Grain maize	427	302	0	302	0
Legurmes	384	302	56	302	0
Oilseeds	499	302	45[a]	302	45
Energy maize	0		0	302	45
Root crops	0	302	0	302	0
Special crops	0	302	0	302	0
Silage maize	427	302	0	302	0
Clover	0	302	0	302	0
Set aside	310	302	0	302	0
Intensive grassland	30	302	0	302	0
Extensive grassland	50	302	0	302	0
Animal production			EUR $head^{-1}$		
Suckler cows	163	0	0	0	0
Fattening bulls	160	0	0	0	0
Sheep	23	0	0	0	0

a) The payments for energy crops were abolished in 2008 after the CAP Health Check, however assumed to be still paid in this study.

Sources: BMVEL (2000A), BMVEL (2005A), KTBL (2001A)

Direct payments from Pillar 2

The payments from Pillar 2 are derived according to MEPL2[27] which includes the regional agri-environmental program MEKA3. In comparison to the reference year the payments for intensive grassland management are decreased to 50 EUR ha^{-1}; payments for extensive grassland and for intercropping are decreased both to 90 EUR ha^{-1}. The compensatory allowances are assumed to be decreased and uniformly paid for cash crop production independently from the yield measure index. Compensatory allowances for fodder area decreased by around 10% to 30%. An overview on the direct payments from Pillar 2 is presented in Table 3.1-4.

[27] MEPL2 is applied in Baden-Wuerttemberg from 2007 to 2013.

Table 3.1-4: Payments of Pillar 2 as modelled in ACRE.

	Compensatory allowance			
	MEKA2 (2000-2006)		MEKA3 (2007-2013)	
	Fodder area [b]	Less profit cash crops [a]	Fodder area [b]	Cash crops [c]
LVZ	EUR ha^{-1}			
<15	178	89	120	25
15	170	85	113	25
16	162	81	106	25
17	154	77	99	25
18	146	73	92	25
19	138	69	85	25
20	130	65	78	25
21	122	61	71	25
22	114	57	64	25
23	106	53	57	25
24	98	49	50	25
25	90	45	50	25
26	82	41	50	25
27	74	37	50	25
28	66	33	50	25
29	58	29	50	25
>30	50	25	50	25

	Agro environmental measures	
	MEKA2 (2000-2006)	MEKA3 (2007-2013)
	EUR ha^{-1}	
Intensive grassland	90	50
Extensive grassland	130	90
Intercropping	110	90

a) Barley, oats, rye, sunflowers, triticale, legumes. b) Clover and grassland.
c) Cash crops excluding fruit and vegetable.

Source: MLR (2005A), MRL (2007A)

Production quotas and market restrictions

In the baseline scenario the mandatory set-aside as well as production quotas to regulate milk and sugar production are assumed to be abolished. However, the production of several crops is restricted by limited availability of production factors (e.g. the suitable production area for sugar beet production and vineyards and stable places for dairy cows).[28]

Prices, costs and yields

Latest available statistical price developments in Germany are used for price assumptions in the scenario year 2015. These prices developments[29] show an increased price level for all

[28] Under the assumption of increases in milk and crop yields a production quota results in a decrease in numbers of hectares or dairy cows.

[29] Reminder: The prices considered in this study are all nominal prices.

commodities. Further price increases in agricultural commodities can be assumed due to several potential developments expected for the supply and demand side in agricultural markets. On the supply side the producer prices can be expected to increase due to higher production costs. The use of UAA for energy crop production might increase the competition for the limited production factor of agricultural area. The expected impacts of climate change might reduce the production in important export countries (e.g. due to decreasing water availability for irrigation in parts of the USA and in Australia cereal production might be reduced in these countries). On the demand side a higher consumer demand is expected due to a growing world population and increases of income levels in developing countries (e.g. China and India, cf. Section 1.2, Bureau et al. (2007).

In Table 3.1-5 the prices assumed in this study are compared with price projections of studies from the FAO/OECD, FAPRI and the vTI. The shaded cells identify deviations from the baseline prices which are less than +/-15 percentage points and thus in an acceptable range. The table shows that most of the assumed price developments in the baseline scenario are in line with price projections in the FAO/OECD study. However for a few relevant prices the FAPRI price projections are closer (e.g. winter barley and milk) and for some prices the deviations with both studies are quite large (e.g. spring wheat). The deviations from vTI prices (published for the vTI baseline for Germany) show only small deviations for the important products wheat and milk, while for animal products the deviations are quite large.[30]

Even though the prices assumed in this study are in a similar price range as the price developments projected in other studies it has to be mentioned that the historical price levels assumed in the scenarios is rather high. However, the advantage of taking the latest historical price data for the simulation of prices for 2015 is that the data refers to an observed and real market situation. On the contrary forecasted prices do not necessarily reflect real market situation.

[30] The prices of the vTI would have been the most representatives to be taken for this study. However, in the time when the model calculation for this study have been made, these vTI prices have not been available.

Table 3.1-5: Price changes for the year 2015 assumed in ACRE and as projected by studies of the OECD-FAO, FAPRI and vTI baselines.

Commodities	Prices in REF	ACRE [a]	OECD-FAO [b]		FAPRI [c]		vTI	
	status	increase 2000-2015	price increase	difference ACRE - other source	price increase	difference ACRE - other source	price increase	difference ACRE - other source
Crop products	**EUR dt^{-1}**	**%**	**%**	**pp**	**%**	**pp**	**%**	**pp**
Winter wheat	11.6	146	147	-1	135	10.2	138	8
Spring wheat	12.2	106	147	-41	135	-29.3	138	-32
Winter barley	11.3	129	149	-20	143	-14.0	142	-13
Spring barley	13.6	153	149	4	143	10.2	142	11
Rye	10.4	141	149	-7	122	19.5	118	23
Oats	10.4	129	149	-19	n.d.	n.d.	127	2
Triticale	--	130	149	-18	n.d.	n.d.	135	-5
Grain maize	12.6	141	149	-7	110	31.7	127	14
Rapeseed	25	128	135	-7	215	-87.3	150	-22
Legumes	12	141	n.d.	n.d.	162	-21	160	-19
Sunflowers	22.4	124	135	-10	185	-61	151	-27
Potatoes	7.8	235	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Sugar beet	5.2	108	127	-19	n.d.	n.d.	n.d.	n.d.
Vegetable	6.4	117	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fruit	40.1	117	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Hop	--	118	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Vine	165.6	100	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Animal products	**EUR $unit^{-1}$**	**%**	**%**	**pp**	**%**	**pp**	**%**	**pp**
Milk [e]	34	99	143	-44	98	1.3	88.7	10
Beef (from bulls) [f]	365	102	105	-2	85	17.1	120	-18
Beef (from calve) [f]	321	91	105	-13	85	6.1	120	-29
Beef (from cow) [f]	110	98	105	-7	85	12.9	120	-22
Breeding heifers [f]	1138	91	105	-13	103	-12.3	120	-29
Young bulls [g]	374	80	105	-25	103	-23.6	120	-40

Commodities	Prices in REF	ACRE [a]	OECD-FAO [b]		FAPRI [c]		vTI	
	status	increase 2000-2015	price increase	difference ACRE - other source	price increase	difference ACRE - other source	price increase	difference ACRE - other source
Animal products	**EUR unit^{-1}**	**%**	**%**	**pp**	**%**	**pp**	**%**	**pp**
Young heifer [g]	250	98	105	-7	103	-5.6	120	-22
Male calves [g]	140	116	105	11	103	12.2	120	-4
Female calves [g]	89	91	105	-13	103	-12.3	120	-29
Pork [f]	132	91	97	-6	102	-10.6	111	-20
Piglets [g]	35	98	97	1	102	-3.8	111	-13
Lambs [g]	66	107	134	-26	117	-10.1	98	9
Poultry [f]	125	111	109	2	110	1	130	-19
Eggs [h]	10	116	n.d.[d]	n.d.	n.d.	n.d.	n.d.	n.d.
Ride horses [g]	600	100	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Notes: a) Historical prices for Germany in the year 2007. Source vTI (2007). b) Price projections. Source: OECD-FAO 2007, OECD-FAO 2003. c) Price projections: Binfield (2007). d) n.d.: no data e) Notes: Unit: 100 kg. f) Notes: Unit: 100 kg slaughter weight. g) Notes: Unit: animal. h) Unit: 100 eggs. n.d. no data i) Source vTI (2010), pp: percentage points

Source: own calculations based on vTI (2007), OECD-FAO (2003), Binfield (2007), vTI (2010)

Production costs and yields

As the prices, so the production costs in this study are considered in nominal terms. The development of the variable production costs is calculated according to Winter (2005: 35). The costs of agricultural input factors increase annually due to a defined inflation rate of 1.5%, derived from historical price indices (Winter 2005: 119-120). This inflation rate is used in this study to calculate the increase of variable production cost in the baseline scenario. The total percentage increase of costs due to inflation in the year 2015 results in 25%. Another type of increase in variable production costs is caused by the assumption of increasing crop yields by a more intensive use of fertilizer and pesticides. The increases in input quantities of the production factor fertilizer provoke increased production costs of +35%. Table 3.1-6 gives an overview of the development of the variable production costs.

Table 3.1-6: Development of yields and variable production costs.

	Annual increase	Total increase	Average [a] yield in 2000	Average [a] yield in 2015	Percentage increase of yields	Percentage increase of costs
Crop yields		dt ha^{-1}			%	
Winter wheat	0.9	13.5	66	79	20	41
Spring wheat	0.9	13.5	56	70	24	33
Rye	1	15	53	68	28	39
Winter barley	0.7	10.5	58	69	18	33
Spring barley	0.6	9	50	59	18	37
Oats	0.5	7.5	51	59	15	31
Grain maize	1	15	91	106	17	34
Silage maize	5	75	459	534	16	33
Legumes	0.5	7.5	34	42	22	39
Potatoes	5	75	309	384	24	33
Sugar beet	3	45	574	619	8	32
Animal performance		kg yr^{-1} cow^{-1}			%	
Milk yield	50	750	4722	5472	16	25
Production costs	%	%			%	
Inflation rate	1.5 [b)]	25			25	
Pesticide costs due to yield increase					35%	

a) Average yield of all districts. b) No yield increase assumed for fruit, vegetable, vine, clover, grassland. b) Except for vine, which 1.5*0.85 = 1.275. The calculation of production cost increase was modified for vine production by assuming a lower inflation. The relative high variable costs for vine production and not simulated yield increases result in high losses when the full inflation of 1.5% is assumed. Thus the inflation was corrected to a total inflation which is for vine costs 1.275% instead of 1.5%. This correction is more a technical adjustment than a valid scenario assumption. Due to the relatively small extension and the special role of vine production, this simple correction can be accepted without concerns of significant distortions of the model.

Source: Winter (2005: 118-119), own calculations

Yield changes in crop and animal production depend also on climatic, biological and technological factors. Climatic factors include e.g. changes of precipitation, extreme weather events, and temperature. Biological factors imply e.g. crop diseases and pests. Changes of technological factors imply technological progress in plant and animal breeding and production techniques. The yield developments in the baseline scenario are assumed to increase only due to technological progress, whereas climatic and biological factors are not considered. Table 3.1-6 presents the assumed developments of variable production costs and yields in the baseline scenario.

Comparison of economic key parameters in the reference year and in the baseline scenario

In order to explain the impacts of policy changes on policy objectives the value of the economic key parameters in the reference year (in the year 2000) and the baseline scenario (in the year 2015) are compared. Tables 3.1-7 and 3.1-8 summarize the values of the economic key parameters (i.e. producer prices, subsidies, variable production costs, gross margins) in the reference year and in the baseline scenario and the percentage development for crops and animal production. The value and developments of gross margins explains partially the extension and the changes in agricultural production, while the production explains status and development of indicators. Extreme increases of gross margin in relevant crops are found for winter wheat, grassland and bulls. For example in the reference year dairy cows and bulls show with 1311 EUR animal^{-1} and 1866 EUR animal^{-1} the highest gross margin of all products, thus, the counties with a high density of dairy and beef cattle show a high level of average total gross margin in the reference year. The development of gross margin for winter wheat of 70% increase let expect a high increase of total gross margin in the baseline scenario for counties with high share of winter wheat production.

Table 3.1-7: Development of average costs, yields, subsidies and gross margins of crop production in averages in all NUTS3 counties.

	Variable production costs			Yields			Producer prices			Subsidies from Pillar 1 and 2			Gross margin		
	REF[a]	CAP2003[b]	Change	REF	CAP2003	Change	REF	CAP2003	Change	REF	CAP2003	Change	REF	CAP2003	Change
	EUR ha^{-1}	EUR ha^{-1}	%	dt ha^{-1}	dt ha^{-1}	%	EUR ha^{-1}	EUR ha^{-1}	%	EUR ha^{-1}	EUR ha^{-1}	%	EUR ha^{-1}	EUR ha^{-1}	%
Winter wheat	662	935	41	68	82	20	12	17	42	302	327	8	458	779	70
Spring wheat	489	651	33	58	72	23	12	13	8	302	326	8	500	604	19
Winter barley	606	843	39	62	72	17	11	15	36	327	327	0	399	567	42
Spring barley	472	628	33	51	60	18	14	21	50	327	327	0	572	963	69
Rye	566	774	37	56	71	27	10	15	50	327	327	0	320	616	93
Oats	461	605	31	51	59	15	10	13	30	327	327	0	380	492	29
Triticale	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Grain maize	772	1033	34	91	106	16	13	18	38	427	327	-23	843	1210	43
Rapeseed	724	962	33	33	33	0	25	32	28	524	372	-29	616	454	-27
Legumes	385	535	39	37	45	20	11	16	45	409	383	-6	434	564	30
Sunflowers	691	916	33	30	30	0	22	28	27	524	372	-29	484	284	-42
Potatoes	1756	2324	32	308	383	24	8	18	125	0	327	100	711	4905	617
Sugar beet	1011	1390	38	576	621	8	5	6	20	0	25	100	1867	2359	26
Vegetable	974	1257	29	637	637	0	6	7	17	0	327	100	2848	3529	24
Fruit	3690	4707	28	300	300	0	40	47	18	0	0	100	8310	9393	13
Hop	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vine	13746	14644	7	121	121	0	166	166	0	0	0	0	6340	5442	-14
Energy maize	759	1021	34	466	541	16	0	3	--	0	372	100	-759	975	-228
Silage maize	759	1021	34	466	541	16	0	0	--	427	327	-23	-332	-694	-109
Clover	339	423	25	76	76	0	0	0	--	50	354	608	-289	-69	+76
Set-aside	213	266	25	--	--	--	0	0	--	310	327	5	97	61	-37
Intercrops	68	85	25	30	30	0	0	0	--	110	90	-18	42	5	-88
Intensive GL	222	278	25	72	72	0	--	--	--	140	404	188	-22	201	269
Extensive GL	79	98	25	28	28	0	--	--	--	180	445	147	101	346	394

a) REF: reference year in 2000, b) CAP2003: baseline scenario in 2015. --: no data

Table 3.1-8: Development of average costs, yields, subsidies and gross margins of animal production in all NUTS3 counties.

	Variable costs			Yields			Prices			Subsidies from Pillar 1 and Pillar 2			Gross margin		
	REF	CAP2003	Change	REF	CAP2003	Change	REF	CAP2003	Change	REF	CAP2003	Change	REF	CAP2003	Change
	EUR head^{-1}		%	EUR head^{-1}		%	EUR head^{-1}		%	EUR head^{-1}		%	EUR head^{-1}		%
Milk [e]	210	263	25	4695	5395	15	34	34	0	0	0	0	1311	1606	23
Beef (from bulls) [f]	110	138	25	0	0	0	365	373	2	160	0	-100	1866	1796	-4
Beef (from calve) [f]	142	178	25	0	0	0	140	162	16	0	0	0	92	-42	-146
Beef (from cow) [f]	-110	-138	25	0	0	0	110	108	-2	163	0	-100	349	232	-34
Breeding heifers [f]	195	244	25	0	0	0	1138	1037	-9	0	0	0	693	546	-21
Young bulls [g]	110	138	25	0	0	0	365	373	2	160	0	-100	1866	1796	-70
Young heifer [g]	110	138	25	0	0	0	250	245	-2	0	0	0	1757	1783	1
Male calves [g]	142	178	25	0	0	0	140	162	16	0	0	0	92	-42	-134
Female calves [g]	122	153	25	0	0	0	0	0	0	0	0	0	39	11	-71
Pork [f]	12	15	25	0	0	0	132	120	-9	0	0	0	78	65	-17
Piglets [g]	170	213	25	0	0	0	35	34	-3	0	0	0	530	473	-11
Lambs [g]	20	25	25	0	0	0	66	71	8	21	0	0	67	46	-31
Poultry [f]	5	6	20	0	0	0	125	139	11	0	0	0	11	12	9
Eggs [h]	7	9	29	0	0	0	10	12	20	0	0	0	29	32	10
Ride horses [f]	0	0	#DIV/0!	0	0	0	600	600	0	0	0	0	600	600	0

Notes: e) Unit: per 100 kg, f) Unit: per head, g) Unit: per 100 kg carcass, h) Unit: per 100 eggs

3.1.3 Analysis of indicator values according to NUTS3 counties

This section describes the development of economic, supply and environmental indicators in the baseline scenario (CAP2003) and compares the indicator values with the status quo in the reference year (REF). The analysis is done at regional level for the NUTS3 counties where agricultural production is represented by 'regional farms' (cf. Subsection 2.3.3).

Development of economic indicator values

The economic indicators are analysed by their regional expression displayed in maps and by average values of the NUTS3 counties[31].

Subsidy volume

Maps 3.1-1 a to f present the developments of subsidy volumes and total gross margin in the baseline scenario in comparison to their values in the reference year. All NUTS3 counties show an increase in subsidy volume (c.f. Map 3.1-1 a). The increase is higher in counties with high shares of grassland (particularly found in Schwarzwald and Schwäbische Alb) than in arable counties with small shares of grassland (in the northern part 'Unterland/Gäue'). The increase in subsidy volume in the grassland dominated counties is caused by increased payments from Pillar 1. In REF 90 EUR ha^{-1} or 130 EUR ha^{-1} are received for the two grassland intensities as payments from Pillar 2 for agri-environmental programs plus the compensatory allowance, depending on the soil fertility. In CAP2003 payments for grassland from Pillar 2 are 50 EUR ha^{-1} or 90 EUR ha^{-1} plus the compensatory allowance of 50 to 120 EUR ha^{-1}, depending on the soil fertility. However, additionally to the payments from Pillar 2 also payments from Pillar 1 for UAA of 302 EUR ha^{-1} are paid (c.f. Map 3.1-1 c), see Subsection 3.1.2.

In arable land counties the significant increase of subsidy volume is also mainly caused by payments for grassland from Pillar 1, even though the number of hectares of grassland is smaller than in grassland counties. The payments from Pillar 1 for grassland compensate partially the losses resulting from reduced payments for crops (e.g. for maize) and livestock (e.g. for bulls). The direct payments for cereals, i.e. the most important arable crop, are with 302 EUR ha^{-1} as high as it is in REF.

[31] Reminder: For the analysis of the economic indicators the development as well as the regional distribution is of interest (cf. Subsection 2.1.3).

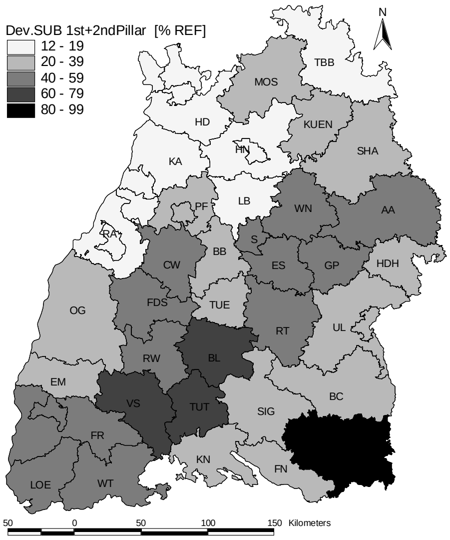
Changes in the amount of payments from Pillar 2 in CAP2003 compared to REF are caused by differences between the agri-environmental programs MEKA1 in REF and MEKA3 in the baseline scenario. However, payments from Pillar 2 have a small impact on the overall change in the payment amount because they are of relative small value (cf. Section 3.1.2). Payments from Pillar 2 for arable land increase because in CAP2003 harmonized compensatory allowances are paid for arable land regardless of the production quality of soil. Thus, also cash crop production area and area with high soil quality receive compensatory allowances in CAP2003 whereas they did not receive allowances in the reference year. Furthermore the payments for intercropping are also increased in CAP2003 due to higher payments in MEKA3 (cf. Map 3.1-1 e). In counties with a large share of grassland the payments from Pillar 2 decrease in CAP2003 due to reduced payments for agri-environmental measures (AEM) for grassland in MEKA3.

The distribution of payments from Pillar 1 and 2 is regionally heterogeneous in REF (cf. Section 2.1) and in the baseline scenario. In REF the average subsidy volume ranges from less than 200 EUR ha^{-1} to less than 350 EUR ha^{-1}; whereas in the baseline scenario average subsidies are greater, ranging from 250 EUR ha^{-1} to less than 500 EUR ha^{-1}.

In the baseline scenario the average payments from Pillar 1 are similar in all counties, ranging from 220 EUR ha^{-1} to 319 EUR ha^{-1} (cf. Map 3.1-1 d). The differences in average payments result from shares of crops which are entitled to special payments (e.g. oilseeds) and crops which are not entitled to direct payments of 302 EUR ha^{-1}.[32] Thus, counties with higher share of special crops receive less payments from Pillar 1 (e.g. HN, S, and FN) (c.f. Map 3.1-1 d). In counties with a high share of grassland and fodder crops the payments for AEM and compensatory allowances result in a higher average subsidy volume from Pillar 2 and in a higher total subsidy volume (c.f. Map 3.1-1 f and Map 3.1-1 b).

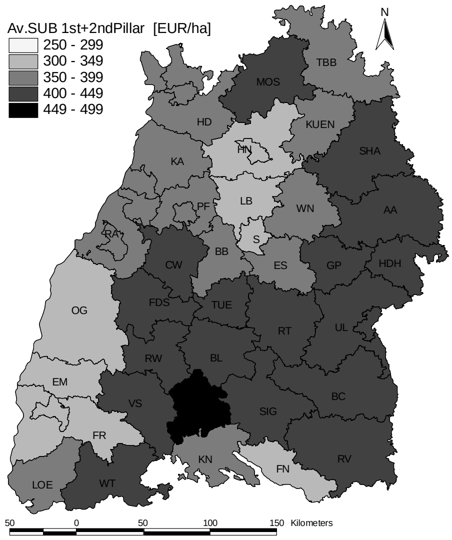
[32] At the time the study was conducted payments from Pillar 1 for wine and fruits have not been decided on and are therefore not considered within the payment of 302 EUR ha^{-1}. However, since 2008 areas with fruits and wine are also entitled to the payments of 302 EUR ha^{-1}. In addition, in the study the area for sugar beet was not considered as being entitled to harmonized payments from Pillar 1, whereas in reality they are also entitled to the payments of 302 EUR ha^{-1} since 2008. Because these areas are of a relative small share of the total UAA in the study region, the differences of development in subsidy volume and total gross margin can be considered as not being relevant.

Map 3.1-1 a: Percentage change of subsidy volume from Pillar 1 and Pillar 2 in CAP2003 compared to REF



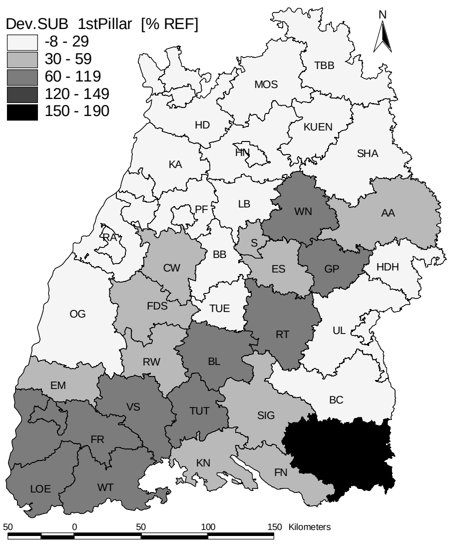
Notes: Unit: %.

Map 3.1-1 b: Average subsidy volume from Pillar 1 and Pillar 2 in CAP2003



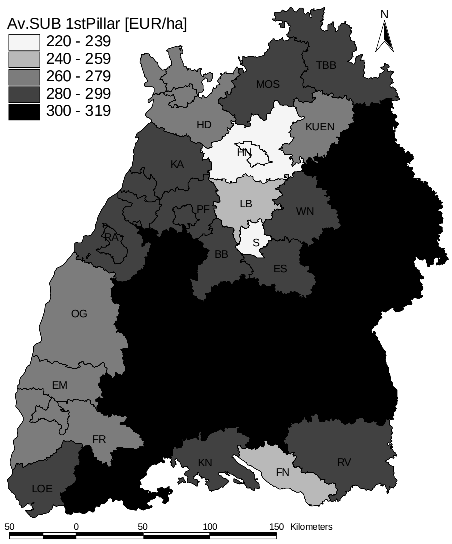
Notes: Unit: EUR ha^{-1}.

Map 3.1-1 c: Percentage change of subsidy volume from Pillar 1 in CAP2003 compared to REF



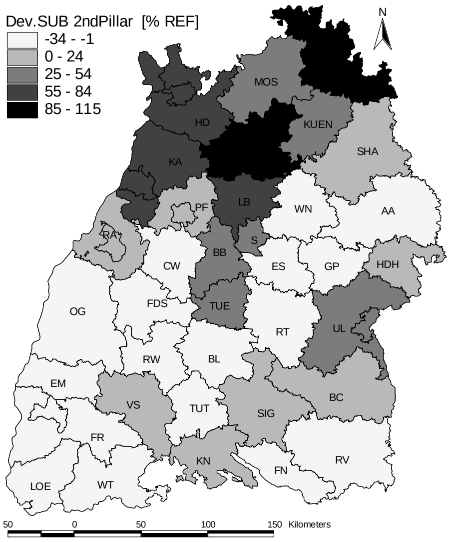
Notes: Unit: %.

Map 3.1-1 d: Average subsidy volume of Pillar 1 in CAP2003.



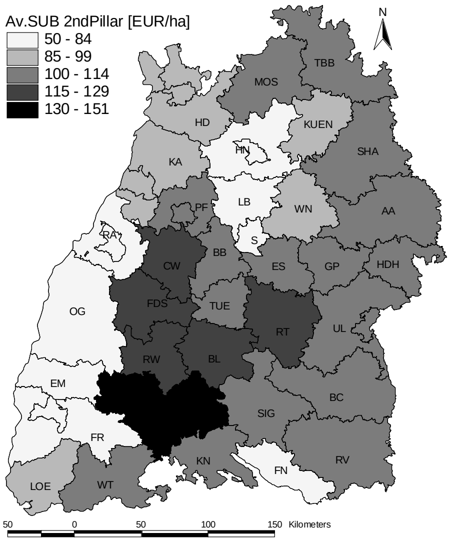
Notes: Unit: EUR ha^{-1}.

Map 3.1-1 e: Percentage change of subsidy volume Pillar 2 in CAP2003 compared to REF.



Notes: Unit: %.

Map 3.1-1 f: Average subsidy volume Pillar 2 in CAP2003.



Notes: Unit: EUR ha^{-1}.

Total gross margin

In all NUTS3 counties the total gross margin volume (including subsidies) increases in the baseline scenario due to increases in subsidies and increases in prices and yields (cf. Map 3.2-1 a and c, Section 3.1.2).

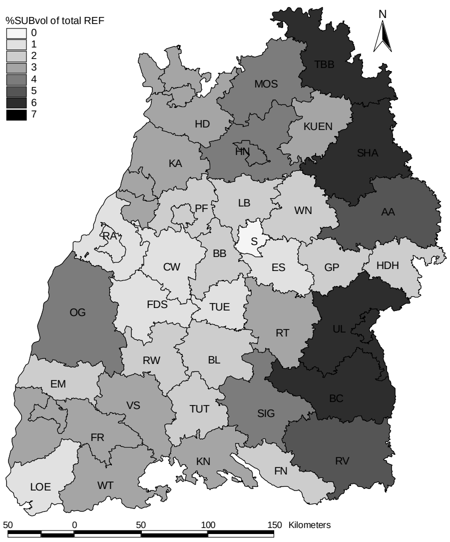
In counties with a high share of cash crops (Unterland/Gäue and Bessere Rheinebene) an extreme increase in total gross margin including subsidies can be observed, this increase is caused by the high price level of cereals in the baseline scenario (e.g. counties KA and RA). In most of the cash crop counties and fodder crop counties the income losses due to reduced direct payments (e.g. for bulls or maize) are overcompensated by increases in agricultural prices. The increase in total gross margin is smallest in NUTS3 counties with a small share of grassland, relatively high share of fodder crop area and a high livestock density. Due to the small area of cash crops in these counties the price increase for cereals do not compensate the losses that are due to the abolishment of livestock payments and the extreme decline in prices for pigs. In the county SHA the animal density of 10 bulls and 500 pigs per 100 ha is high. Thus, the reduction of livestock results in a decrease of TGM (when considering only production, and excluding subsidies).

In the grassland counties (Schwarzwald and Schwäbische Alb) the increase of TGM is caused by the increase in direct payments from Pillar 1 and 2. This correlation is indicated by an increase which is higher for TGM including subsidies than for TGM excluding subsidies.

Beside changes in direct payments also the changes in crop yields and prices, the abolishing of mandatory set-aside area and the increase of milk yield result in increases of the TGM. However, the most important increases of total gross margin are caused by increased payments for grassland from Pillar 1 and 2 and by increased cereals prices.

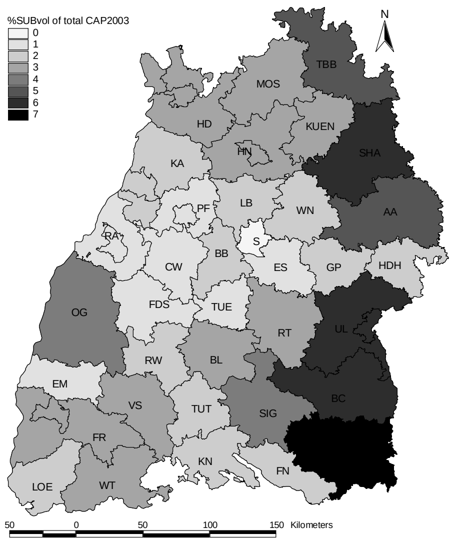
The distribution of total gross margin is heterogeneous in REF and in the baseline scenario (cf. Map 3.1-2 b and d). Counties with a high share of special crops (e.g. counties in Geringere Rheinebene: OG, EM, FR) as well as counties with intensive animal production in the Western part of Baden-Wuerttemberg show a high average of TGM. The county RV (in Allgäu), and the counties SHA and KUEN (in Hohenlohe) show the highest TGM. Thus, in counties which have a high level of TGM in REF the increased prices and changed direct payments result also in higher average total gross margins in the baseline scenario.

Map 3.1-1 g: Percentage share of total subsidy volume in REF.



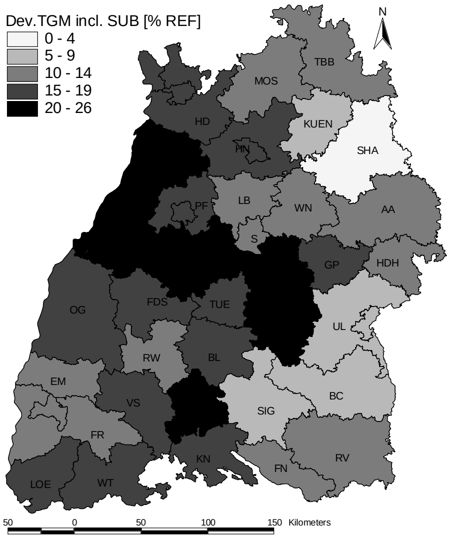
Notes: Unit: %; basis: total SUBvol in BW.

Map 3.1-1 h: Percentage share of total subsidy volume in CAP2003.



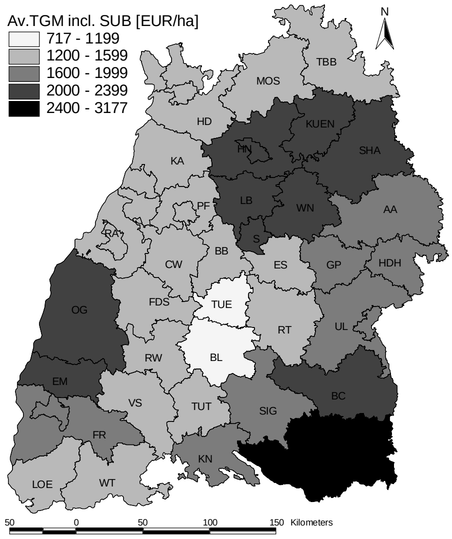
Notes: Unit: %; basis: total SUBvol in BW.

Map 3.1-2 a: Percentage change TGM incl. SUB in CAP2003 compared to REF.



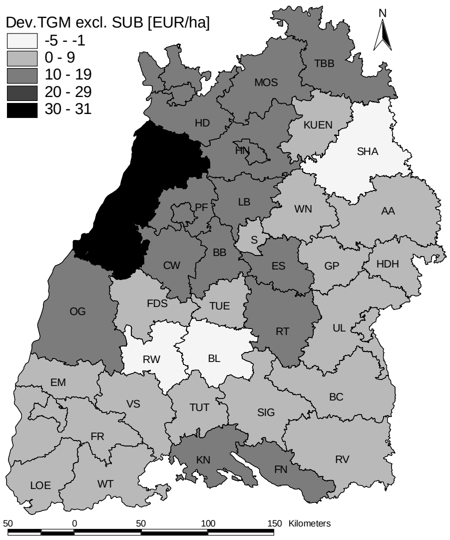
Notes: Unit: %.

Map 3.1-2 b: Average TGM incl. SUB in CAP2003.



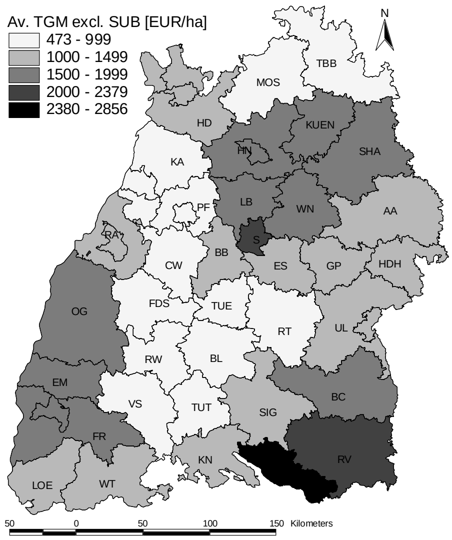
Notes: Unit: EUR ha^{-1}.

Map 3.1-2 c: Percentage change TGM excl. SUB in CAP2003 compared to REF.



Notes: Unit: %.

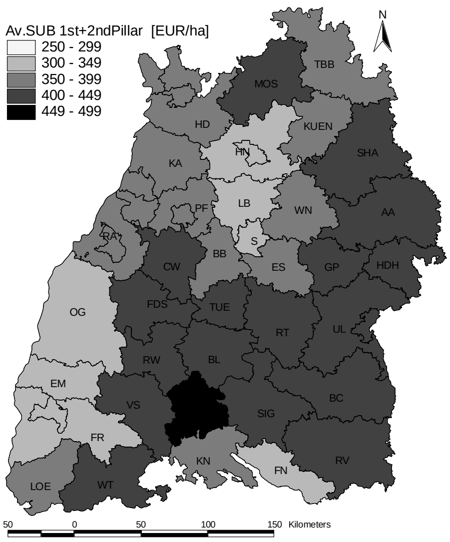
Map 3.1-2 d: Average TGM excl. SUB in CAP2003.



Notes: Unit: EUR ha^{-1}.

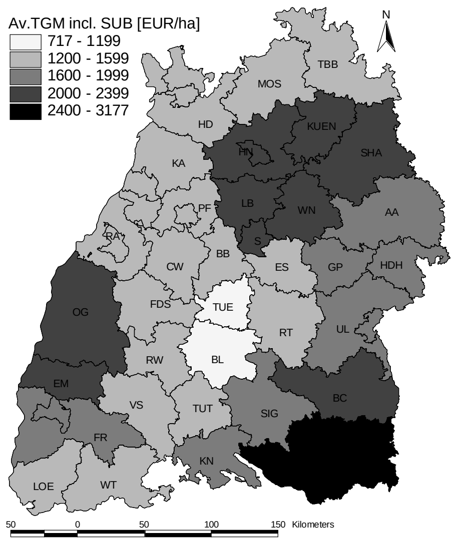
In the baseline scenario the average subsidies and the average TGM in the model region show a heterogeneous distribution (cf. Map 3.1-1 b and Map 3.1-2 b). In this study at hand the middle interval of income (from 1600 to 1999 EUR ha^{-1}) is assumed as a benchmark which represents the medium income level. This medium income level is reached in some counties (e.g. AA, GP, HDN) with relative high direct payments of 400 to 449 EUR ha^{-1}, while farms in FR and KN reach this income class even though they receive a lesser amount of direct payments. In counties with higher direct payments the direct payments compensate for losses in livestock subsidies and reach the medium income level. On the other hand, some counties (e.g. SHA, BC, RV) achieve a high income because of both high direct payments and also because of an intensive production. On the contrary, in counties with extensive production (e.g. TUE, BL) the medium income level cannot be reached even with high direct payments. Thus, depending on the county the direct payments over- or under-compensate for reaching a medium average income level in the NUTS3 counties.

Map 3.1-1 b: Average subsidy volume of Pillar 1 and Pillar 2 in CAP2003.



Notes: Unit: EUR ha^{-1}.

Map 3.1-2 b: Average TGM incl. SUB in CAP2003.



Notes: Unit: EUR ha^{-1}.

Impact of costs, yields, prices and subsidies on gross margin

Tables 3.1-7 and 3.1-8 summarize the values of the economic key parameters (i.e. producer prices, subsidies, variable production costs, gross margins) in the reference year and in the baseline scenario and the percentage development for crops and animal products. The values are averages of all NUTS3 counties and do not represent the different production conditions in the counties. However, together with the information of agricultural production structure, the average values can be used to explain the development of the economic indicators and their distribution in the scenarios.

Extreme increases of gross margins are found for winter wheat, grassland and bulls. Being of high absolute gross margin the large extension of these products result in high absolute values of total gross margin, and explains the changes of income. For example with a gross margin of 1606 EUR per animal dairy cows are of the highest gross margin in the baseline scenario, resulting in a high income level for NUTS3 county RV, where the density of cows is high (cf. Map 3.1-2 b). The same applies for winter wheat which contributes with a large extension and a gross margin of 779 EUR ha^{-1} to the high income level in counties with a dominating cash-crop and fodder crop production. These products are of highest gross margin values and of a large extension in the reference year.

Development of supply indicator values

On the one hand changes in crop production describe the changes in food, fodder and energy crop production or a conversion of arable land, grassland and abandoned UAA. On the other hand changes in crop production also have an influence on production intensity.

Crop production

Cereals production increases especially in counties with a high share of cereals area particularly in the fertile northern part of the study region (Gäue and Unterland) and in the western fodder crop counties (Oberland/Donau). Outside of these VG there are also single counties with a high share of cereals area and an increasing cereals area (e.g. KN. FDS, BB) (cf. Map 3.1-2 a). In the extensive crop production counties Schwarzwald and Schwäbische Alb (e.g. VS, TUT, BL) cereals area decreases because the unfavourable production conditions result in relative low cereal yields, which does not provoke profitable increases in cereals area. In these counties particularly the acreages of spring wheat are reduced, with the free-set arable area converted into grassland. The natural conditions in the counties in the Geringere Rheinebene (FR, OG, EM, RA) allow the production of grain maize. Due to increased maize yields (+17%) and prices (+41%) the grain maize area is extended (cf. Map 3.1-2 b).

The area of oilseeds is reduced in almost all counties. This is due to significantly reduced payments from Pillar 1 and Pillar 2 for winter rapeseed (from 499 EUR ha^{-1} in REF to 347 EUR ha^{-1} in CAP2003) (cf. Map 3.1-3 b).

The extension of fodder crop area is small with at most 4% of UAA and the changes are of minor impact for regional land use (cf. Map 3.1-3 d). However, within fodder crops area (the aggregated area of silage maize and clover) and cattle feeding several changes appear which can be interpreted as an extensification in fodder crop production. The reduction and extensification of fodder crop area is driven by three different influences:

(1) Reduced demand for fodder crop area

Fodder crop area demand, particularly for silage maize, is reduced due to the increase of fodder crop productivity and due to the reduced demand for fodder crop area. The increase of productivity is caused by increased crop yields; while the reduced demand is caused by a declined number of fattening bulls.

(2) Changed competition of fodder crops with respect to gross margin

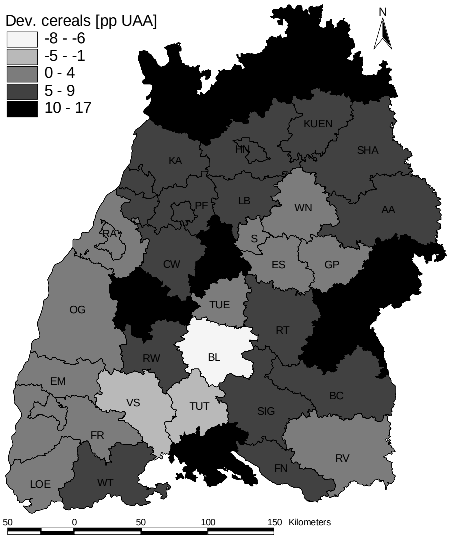
The silage maize area that is not demanded for fodder production is replaced partially by the fodder crop clover, which's gross margin has increased significantly. The payments from Pillar 1 of 302 EUR ha^{-1} increased the (still) negative gross margin of clover from -289 EUR ha^{-1} to -69 EUR ha^{-1}, i.e. by 109% while the negative gross margin of silage maize further decreased from -332 EUR ha^{-1} to -694 EUR ha^{-1} (-76%) (cf. Table 3.1-7). Therefore, with respect to the gross margin clover is the more favourable fodder crop compared to silage maize.

(3) Changes in dairy feeding

Due to the reduction in bull production the silage maize area is partially set free from bulls feeding and used for dairy cows feeding, i.e. the increased area of clover is used for feeding dairy cows. Clover substitutes partially fodder from intensive grassland, which is converted into extensive grassland area.

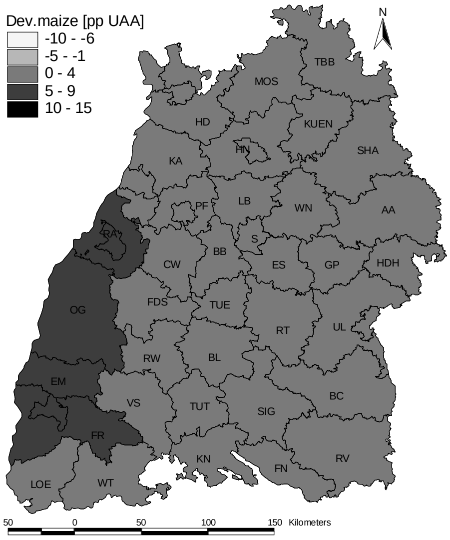
In intensive grassland counties in Allgäu and Geringere Rheinebene (RV, EM) and in Schwarzwald (VS, RW) silage maize is rather used for dairy cattle feeding than for bulls fattening. Due to an unchanged dairy cow stock this fodder area is also kept unchanged. In intensive grassland counties feeding from arable fodder is stable, occurring changes in these counties appear in form of grassland intensification.

Map 3.1-3 a: Change of cereals area in CAP2003 compared to REF.



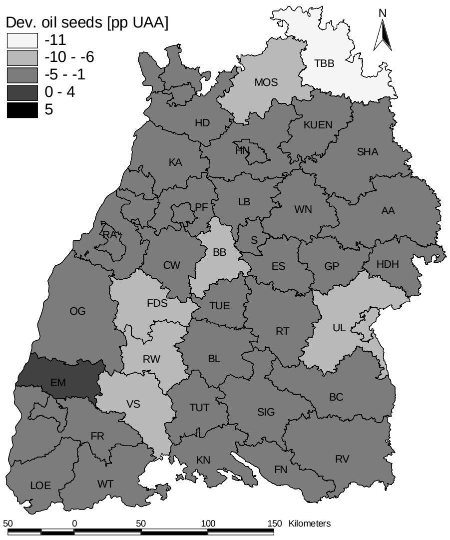
Notes: Unit: pp UAA.

Map 3.1-3 b: Change of maize area in CAP2003 compared to REF.



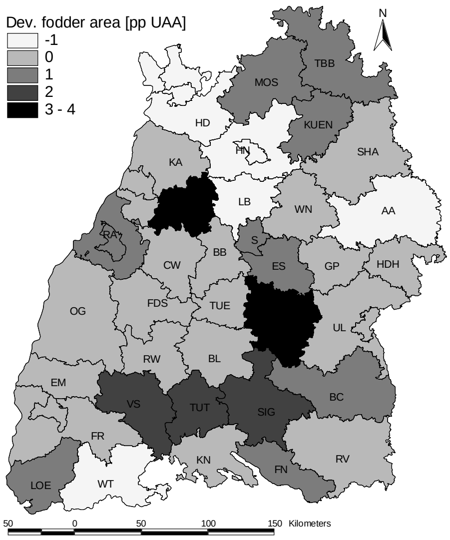
Notes: Unit: pp UAA.

Map 3.1-3 c: Change of oil seeds area in CAP2003 compared to REF.



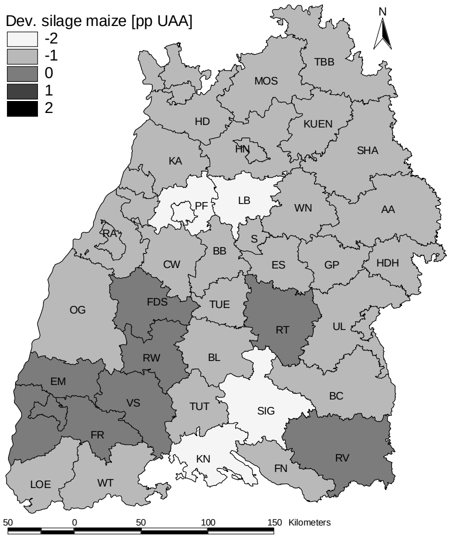
Notes: Unit: pp UAA.

Map 3.1-3 d: Change of fodder crops area in CAP2003 compared to REF.



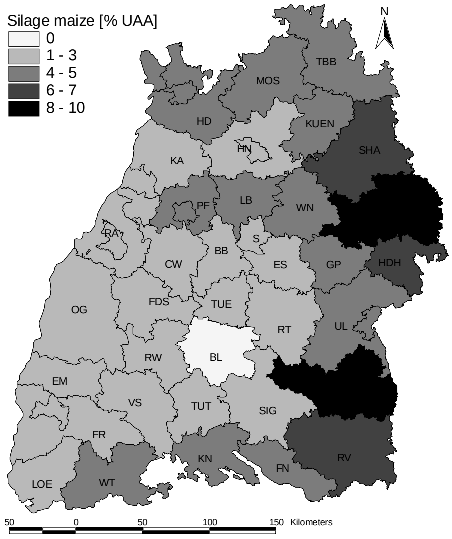
Notes: Unit: pp UAA.

Map 3.1-3 e: Change of silage maize area compared to REF.



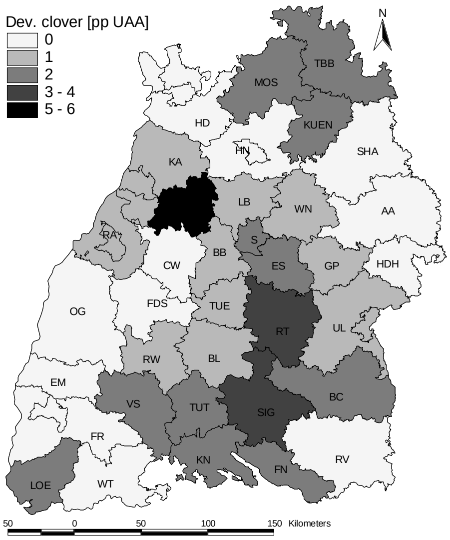
Notes: Unit: pp UAA.

Map 3.1-3 f: Silage maize area in CAP2003.



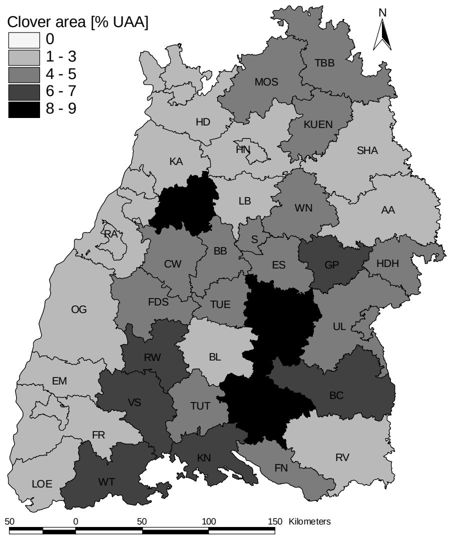
Notes: Unit: % UAA.

Map 3.1-3 g: Change of clover area in CAP2003 compared to REF.



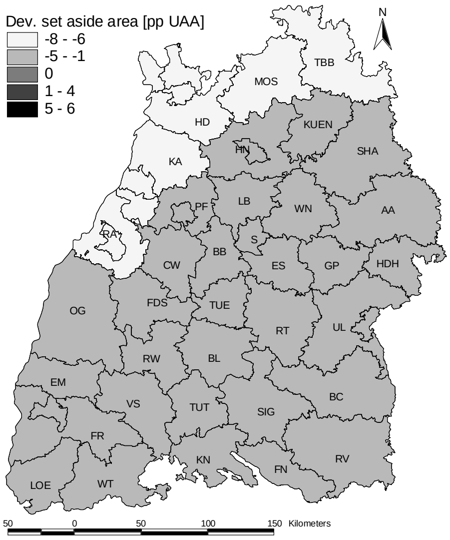
Notes: Unit: pp UAA.

Map 3.1-3 h: Clover area in CAP2003.



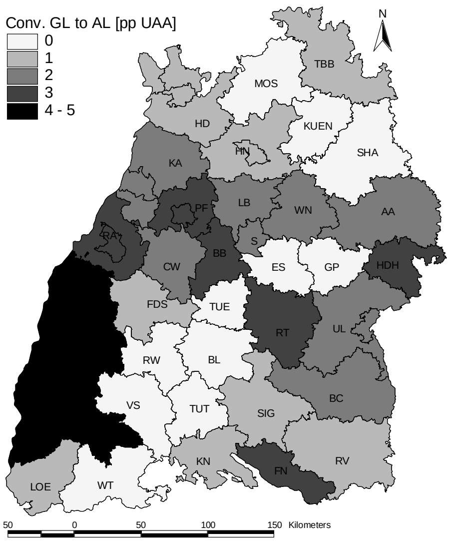
Notes: Unit: % UAA.

Map 3.1-3 i: Change of set-aside area in CAP2003 compared to REF.



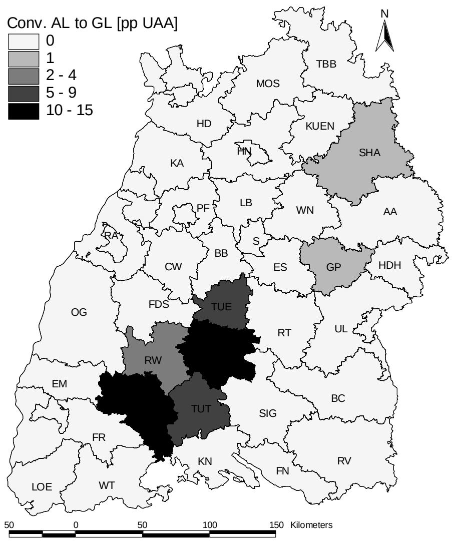
Notes: Unit: pp UAA.

Map 3.1-3 j: Conversion of grassland into arable land in CAP2003 compared to REF.



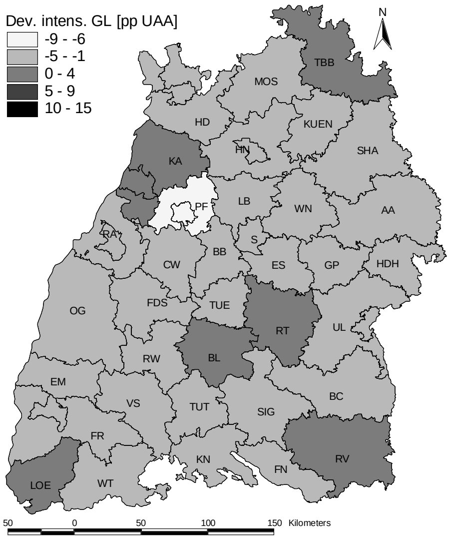
Notes: Unit: pp UAA.

Map 3.1-3 k: Conversion of arable land into grassland in CAP2003 compared to REF.



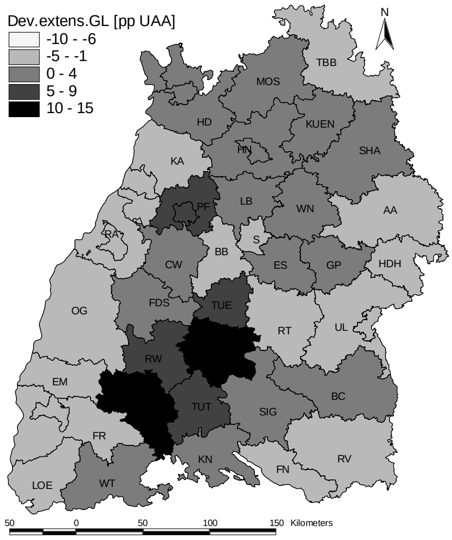
Notes: Unit: pp UAA.

Map 3.1-4 a: Change of intensive grassland area in CAP2003 compared to REF.



Notes: Unit: pp UAA.

Map 3.1-4 b: Change of extensive grassland area in CAP2003 compared to REF.



Notes: Unit: pp UAA.

Crop production intensity

The intensity of crop production is measured by the percentage share of intensive land use and intensive crop activities. For example the conversion of set aside area to arable land under production and the conversion from grassland into arable land imply an intensification in agricultural land use, while a change vice versa implies an extensification (cf. Table 3.1-7).

Map 3.1-4 c presents the development of intensive land use in the baseline scenario. Due to abolishment of mandatory set-aside the set-aside area is reduced in all counties to zero. Thus, more land is under intensive arable production. Most of the counties convert grassland into arable land by less than the allowed limit of 10% of grassland. In this range conversion of grassland is allowed according to the cross compliance requirements (retaining of permanent grassland)[33] (cf. Section 1.1). The converted arable land is used to produce for example intensive crops such as winter wheat and spring barley.

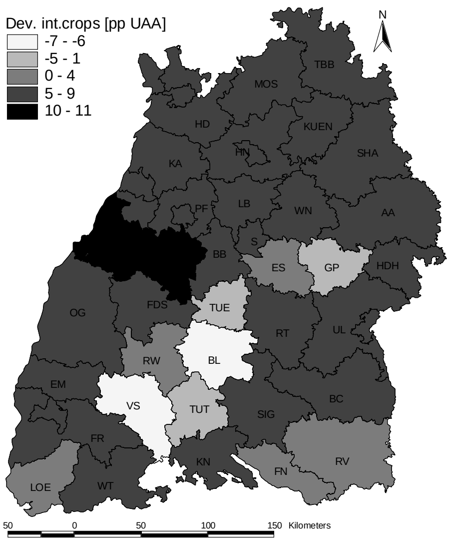
The conversion from arable land into grassland is an extensification of land use that occurs in only few extensive counties in Schwarzwald and Schwäbische Alb (e.g. VS, BL), however also there only few shares of arable land are converted into grassland. In general, a conversion

[33] Since the analysis is at NUTS3 level exceptions from this 10% rule which is applied on farm level are not considered in this study.

of arable land (used for production of profitable cash crops) into grassland seems to be not plausible with respect to the optimization of the total gross margin.

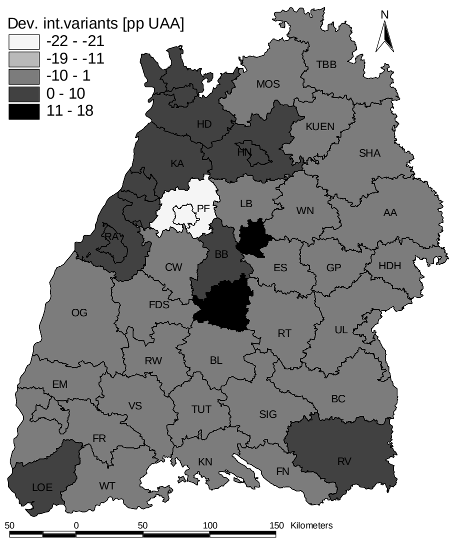
Map 3.1-4 d presents the development of intensive crop variant activities in the baseline scenario. In the northern NUTS3 counties which are located in the VG Besserer Rheinebene, Unterland/Gäue (cf. Subsection 2.2.1) the increase in area of intensive variants, particularly in cereals production, results in intensification in cash crop variants. In most of the counties extensification of crop variants results from conversion of intensive grassland into extensive grassland area. Grassland usage tends to be extensified, except in few counties e.g. RV, LOE, RT, where intensive grassland is extended for fodder production for dairy farming (cf. Map 3.1-4 a, b). Smaller yields resulting from extensification of grassland are compensated by decreased fodder demand and an increase of productivity of arable fodder. Thus, the results project an increase in extensive grassland variant with higher payments from agri-environmental programs.

Map 3.1-4 c: Change of intensive crops area in CAP2003 compared to REF.



Notes: Unit: pp UAA.

Map 3.1-4 d: Change of intensive variants in CAP2003 compared to REF.



Notes: Unit: pp UAA.

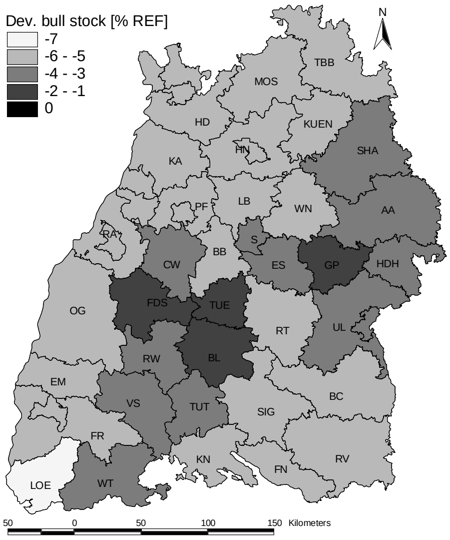
Animal production

Dairy cows stock in the baseline scenario does not change in the counties. The gross margin of dairy cows is not affected by changes in direct payments. Increases in milk yields and high milk price levels result in increased gross margin (cf. Table 3.1-8). Since the milk quota is supposed to be abolished milk production increases under an unchanged number of dairy cows, which is restricted by the stable capacities in REF.

Maps 3.1-5 a and b show the developments of bulls and pigs stocks. In the majority of the counties bulls and pig stocks decrease homogenously between 5% and 6% and between 14% and 13% respectively. This homogenous reduction results from the homogenous decrease of gross margin of animal production due to abolished subsidies for bulls and decreased prices for pigs. Gross margins of animal production are equal in all counties. The profitability of animal production is also affected by changes in fodder crop production, i.e. the yields and costs of fodder production. This aspect is not implied in the gross margin calculation and should be added for more detailed information of change of profitability of animal products. Furthermore the fodder crop usage should be included in the calculation of gross margin. However in this study the gross margin is calculated without considering changes in fodder costs because the gross margin alone excluding this detail already explains the effects observed sufficiently.

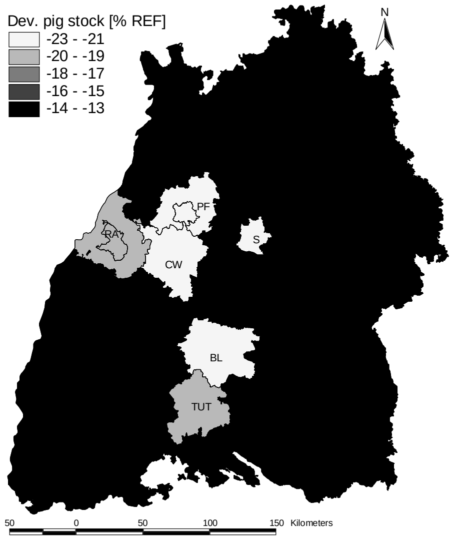
The changes in costs, prices and direct payments for animal production result in a similar decrease of the gross margin function, which explains the similar change in each county. The animals stock is extended in each county up to an optimized level, which is defined by the similar shifted gross margin functions according to the restrictions of stable capacities and fodder. As changes are calculated as percentage changes, counties with smaller animal density are more sensitive to changes, i.e. tend to show a greater percentage decrease (e.g. in Schwarzwald and Schwäbische Alb where animal density is less than 80 pigs per ha and less than 6 bulls per 100 ha). However, the absolute value of reduction might be rather small. The fodder crop counties with high animal density, e.g. in Hohenlohe and Western Baden-Wuerttemberg, are specialized in fodder and animal production and show small percentage changes due to a high absolute number of animals.

Map 3.1-5 a: Percentage change of fattening bulls in CAP2003 compared to REF.



Notes: Unit: %.

Map 3.1-5 b: Percentage change of fattening pigs in CAP2003 compared to REF.



Notes: Unit: %.

Developments of environmental indicator values

Since intensity in crop production increases, the environmental indicators show an increase of environmental pressure. Thus, in general the analysis of the environmental indicators nitrogen emission, soil erosion, and GHG emission show an increase while the application of environmental programs tends to decrease.

Nitrogen input

Maps 3.1-6 a to e present the changes of nitrogen input and the average total nitrogen input in the baseline scenario. The extend of nitrogen emissions depends on the one hand on nitrogen from livestock manure and on the other hand on mineral nitrogen from mineral fertilizer applied for crop production. The sum of organic and mineral nitrogen input determines the total risk of nitrate emissions. The risk of nitrogen emissions increases with increased input of mineral fertilizer and manure. Thus, the unbalanced value of nitrogen input is used as indicator for the risk of nitrogen emissions from agricultural production (cf. Winter 2005: 130).

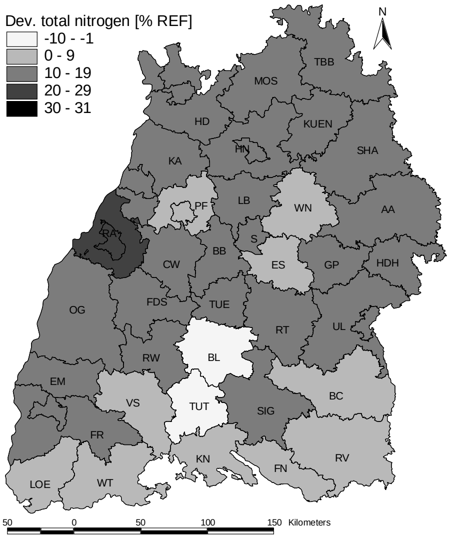
In most of the counties the total nitrogen input is increased by 10% to 20% (cf. Map 3.1-6 a), resulting from an increased use of nitrogen in order to achieve increased crop yields (cf. Map 3.1-6 c). Organic nitrogen input tends to decrease in all counties due to reduced bulls and pig stocks (cf. Map 3.1-6 e), with the size of organic nitrogen input reduction depending on the absolute reduction of livestock. The scale of changes in total nitrogen input depends on the changes in organic and mineral nitrogen and on the level of average nitrogen input. Thus, extensive counties like e.g. BL or TUT show a relative extreme decrease in total nitrogen, organic nitrogen and mineral nitrogen input, since the level of average input of all three indicators is absolutely low in this counties. Correspondingly, small changes in counties with high average nitrogen input are absolutely large. The average total nitrogen input is highest in fodder crop counties with a high animal density (i.e. counties in Bauland/Hohenlohe, Oberland/Donau and Allgäu). The high values result from high levels of organic nitrogen input and of nitrogen demand for fodder crops and cereals production. In the intensive grassland county RV the high total nitrogen value is caused by organic nitrogen input from dairy production. In the counties HN and LB the nitrogen input demanded by crop production result in high total nitrogen values. The smallest nitrogen input is found in the extensive counties of Schwarzwald and Geringere Schwäbische Alb.

Erosion potential

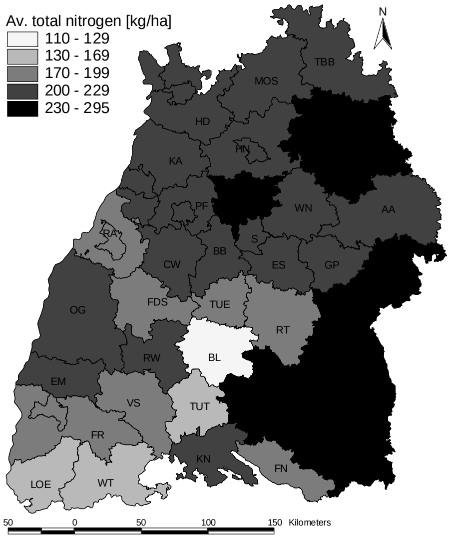
Map 3.1-6 g presents the change of erosion potential in the baseline scenario and Map 3.1-6 h presents the erosion potential as percentage compared to the erosion potential of uncovered fallow land. The erosion potential indicates the risk of phosphate emissions from agriculture (Winter 2005: 132) and depends on the intensity of crop production as well as on the share of intensive crops (e.g. maize) and conversion activities (i.e. conversion of grassland to arable land). Due to high shares of cereals and grain maize, erosion potential is high in the cash crop counties of Unterland/Gäue and in Rheinebene (Map 3.1-6 g, h). The erosion potential increases due to the extension of intensive arable crop area such as cereals and especially maize (including grain and silage maize). Furthermore, the intensification by the conversion of grassland into arable land as well as the conversion of set-aside area into agriculturally used arable land increases the erosion potential. In the extensive counties of Schwarzwald and Schwäbische Alb the erosion potential tends to decrease due to conversion of arable land into grassland (cf. Map 3.1-3 k).

Map 3.1-6 a: Percentage change of total nitrogen input in CAP2003 compared to REF.

Map 3.1-6 b: Average total nitrogen input in CAP2003 compared to REF.



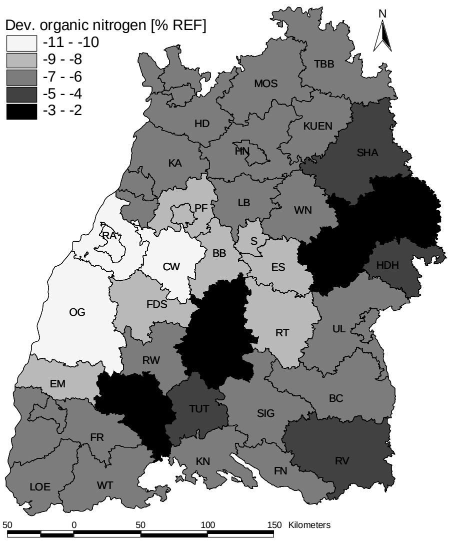
Notes: Unit: %.



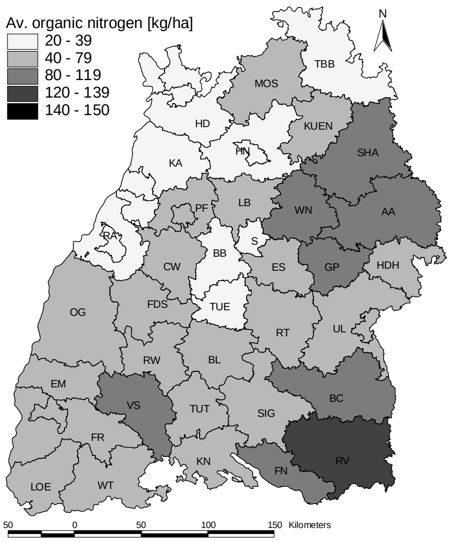
Notes: Unit: kg ha^{-1}.

Map 3.1-6 c: Percentage change of organic nitrogen input in CAP2003 compared to REF.

Map 3.1-6 d: Average organic nitrogen input in CAP2003 compared to REF.

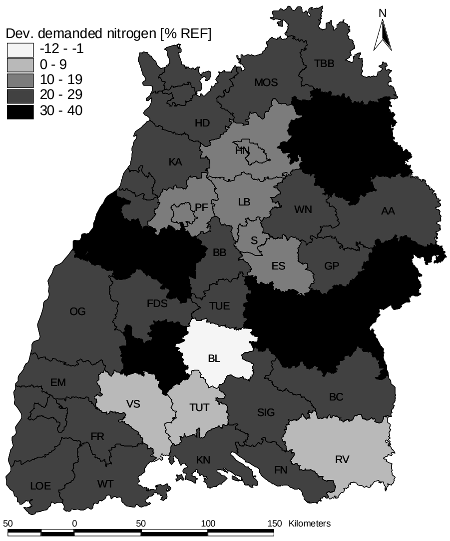


Notes: Unit: %.



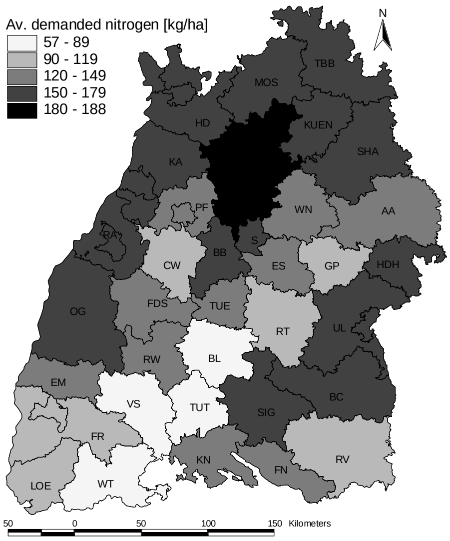
Notes: Unit: kg ha^{-1}.

Map 3.1-6 e: Percentage change of demanded nitrogen input in CAP2003 compared to REF.



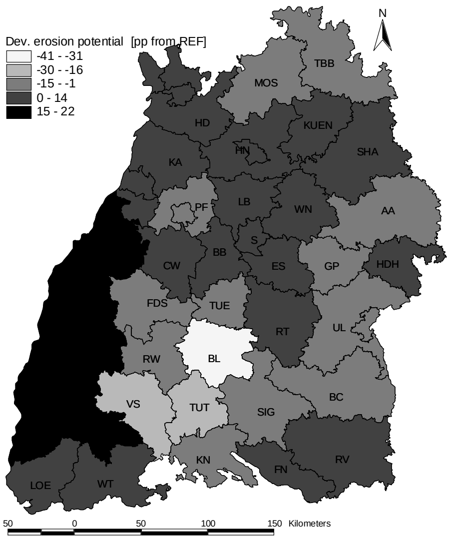
Notes: Unit: %.

Map 3.1-6 f: Average demanded nitrogen input in CAP2003 compared to REF.



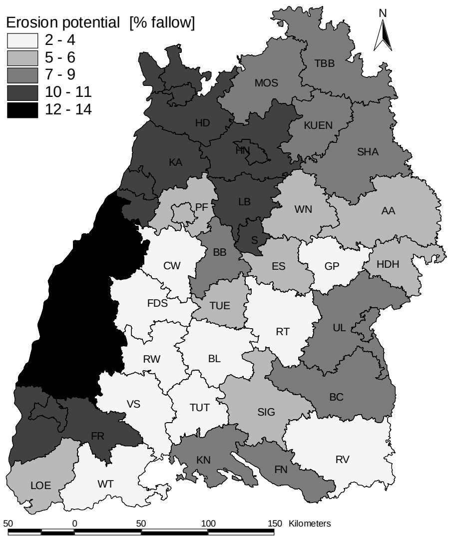
Notes: Unit: kg ha^{-1}.

Map 3.1-6 g: Percentage change of erosion potential in CAP2003 compared to REF.



Notes: Unit: %.

Map 3.1-6 h: Erosion potential in CAP2003 compared to REF.



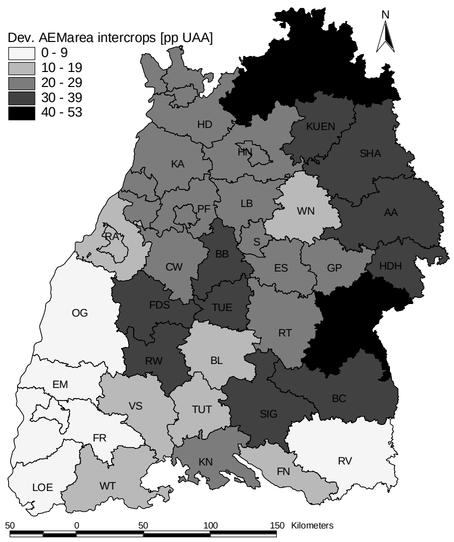
Notes: Unit: % of uncovered fallow.

Weighted nitrogen input and erosion potential

Intercropping is a measure to reduce and to avoid soil erosion and nitrogen leaching. In order to consider the impact of intercropping the change of the indicators for nitrogen and soil erosion are weighted by the acreage of intercrops. Maps 3.3-7 o and p present the status of intercropped area in the baseline scenario and the changes of in CAP2003 compared to REF. Since intercropping is applied in crop production, the share of intercrop area is higher in counties with high share of arable land and cereals production than in the grassland dominated counties. Most of the arable counties increase the share of intercrops by at least 20pp. The extensive grassland counties increase their intercrops area between 10 and 20pp. The gross margin of intercrops decreases from MEKA1 to MEKA3 due to a reduction of direct payments by 20 EUR ha^{-1}, but the gross margin is in the CAP2003 scenario with 5 EUR ha^{-1} still positive and profitable. Intercropping is applied on areas used for production of most of the cereals, rape seed and fodder beans. It is not applied on areas used for production of maize, sunflowers or special crops. Smaller increases of intercrop area are found in counties with high shares of grain and silage maize in Geringere Rheinebene (grain maize about 20% to 30% of UAA) and in Allgäu (silage maize share 10%). Intercropping is defined for arable land used for production of crops which are harvested earlier than autumn (Winter 2005: 114-115). Thus, in counties with high share of maize area the intercropping is applied to less area than in counties with larger cereals and small maize areas.

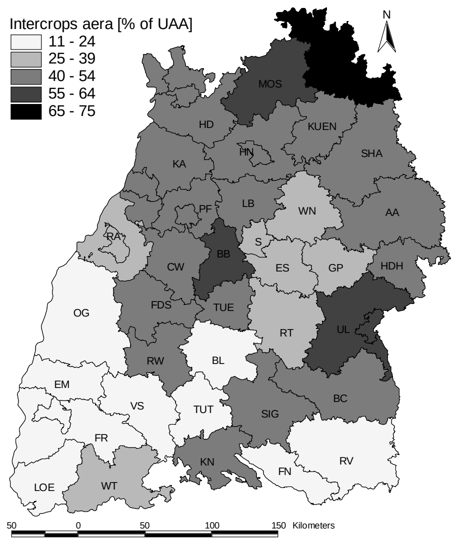
The impact of intercropping on nitrogen emissions and soil erosion depends on many specific factors such as soils, slope and crops. Thus, a regional representation of the impact of intercropping is only a rough attempt to simulate the impact of intercropping. It is assumed that in all counties for all crops one hectare of intercrops reduce nitrogen emission and erosion by 40%. This 40% reduction are used to calculate a weighted value of the indicators nitrogen and erosion emissions. The weighted values represent indicator values corrected by the impact of intercropping activity. For simplification the weighting is applied to the nitrogen emissions and erosion potential of the complete UAA, although in practise it affects only the arable land (cf. Appendix 2.1). The development of the weighted emission indicators is about 10pp less than the development of emission indicators not weighted. Thus, development of the indicator values show that in some counties the nitrogen input turns from increase into a decrease. The weighted nitrogen emissions result only in Rheinebene and in several cash crop and fodder crop counties in slightly increased emissions. The weighted erosion potential is also decreased in most of the counties. However, in counties of Rheinebene and in Allgäu (county RV) even the weighted erosion potential indicates an increase of erosion potential caused by grain and silage maize, which cannot be compensated by intercrop area.

Map 3.1-7 o: Percentage change of intercrops area in CAP2003 compared to REF.



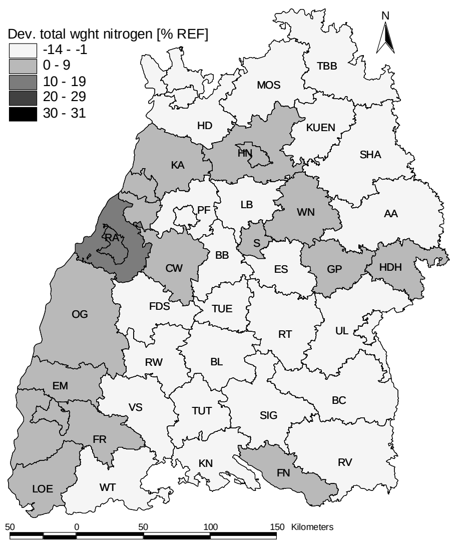
Notes: Unit: pp UAA.

Map 3.1-7 p: Intercrops area in CAP2003.



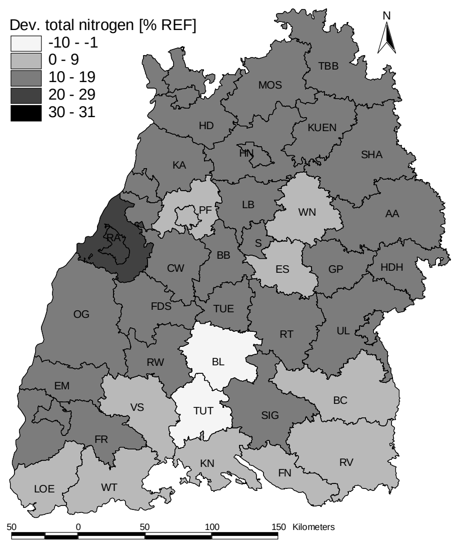
Notes: Unit: % UAA.

Map 3.1-8 a: Percentage weighted total nitrogen input in CAP2003 compared to REF.



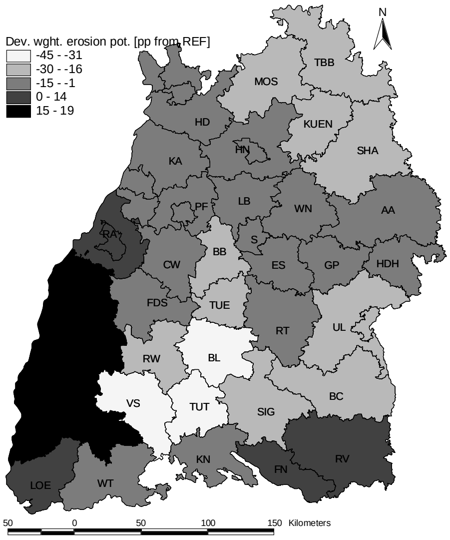
Notes: Unit: %.

Map 3.1-8 b: Percentage of total nitrogen input in CAP2003 compared to REF.



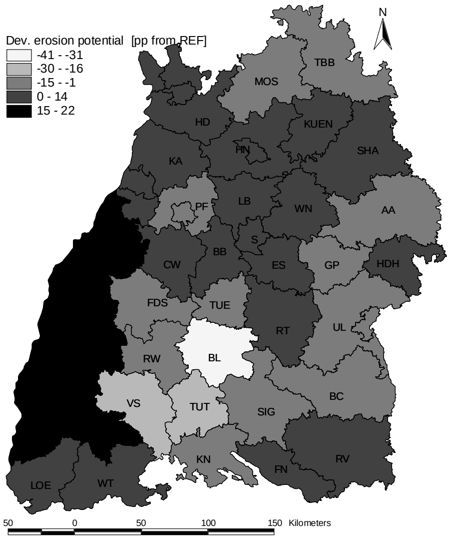
Notes: Unit: %.

Map 3.1-8 c: Percentage of weighted erosion potential in CAP2003 compared to REF.



Notes: Unit: %.

Map 3.1-8 d: Percentage of weighted erosion potential in CAP2003 compared to REF.



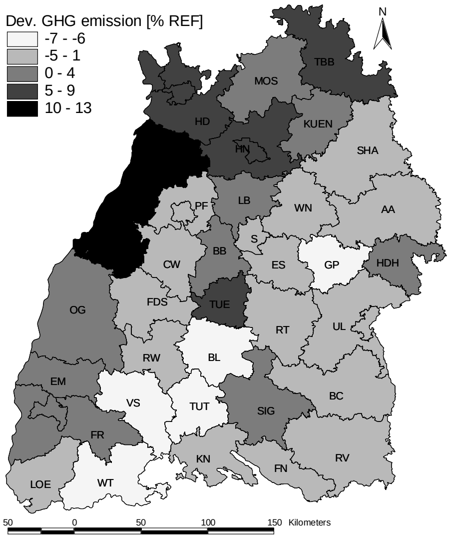
Notes: Unit: %.

GHG emissions

Maps 3.1-6 i and j present the change of GHG emissions and the average GHG emissions in the baseline scenario. GHG emissions depend on livestock numbers of methane emitting ruminants. The amount of produced manure and the input of mineral fertilizer influence the emission of NOx gases. Furthermore, the conversion of grassland into arable land sets CO_2 free. For details on the calculation of the indicator of GHG emissions (cf. Appendix 2.1.).

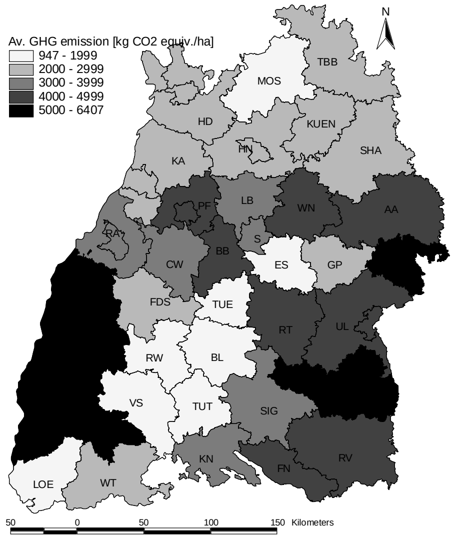
In the baseline scenario GHG emissions tend to decrease in most of the counties in the Western half of the study region due to reduced livestock numbers. In Rheinebene the counties show a rise in GHG emissions due to large shares of converted grassland and a high demand for mineral nitrogen. In this region the emission reduction due to decreased livestock is only small and cannot compensate for the increased GHG emissions resulting of changes in land use. Highest GHG emissions appear here and also in the fodder crops counties with intensive cattle production (e.g. HDH and BC).

Map 3.1-6 i: Percentage change of GHG emissions in CAP2003 compared to REF.



Notes: Unit: %.

Map 3.1-6 j: Average GHG emissions in CAP2003 compared to REF.



Notes: Unit: kg ha^{-1}.

Potential AEM area

Maps 3.1-7 a and b present the change of potential AEM area and the potential total AEM area in the baseline scenario. The potential AEM area represents the possible UAA on which agri-environmental measures could be applied according to the definition described in Section 2.1.[34] Depending on the regional extension of the activities associated with the AEM of the MEKA3 program, the extension and the development of the potential AEM area are regional heterogeneous. The extensive counties of Schwarzwald and Schwäbische Alb as well as the intensive cash crop districts of the Bessere Rheinebene show higher shares of AEM area, between 120% and 180% of UAA. The share of UAA exceeds 100% because it is possible to apply more than one AEM on the same hectare. For example one hectare of set-aside area can be part of the AEM measures 'crop rotation of four crops' and at the same time also 'greening of set-aside area'. Thus, the same hectare counts twice and the total AEM area exceeds the total available area of UAA.

In single counties the increase of AEM area results from the increase of the AEM 'regional typical meadows'. Decreases of AEM area are caused by reduction of area under the measures 'crop rotation of four crops', 'greening on arable area in autumn' and 'greening on set-aside area'. In counties which show a decrease of AEM on arable area this results from the

[34] More details on the calculation of the AEM are given in Section 3.5.

conversion of arable land into grassland. The AEM area is in arable cropping counties especially in cash crop counties higher due to the possibility to apply several AEM at the same time on the same hectare of arable land.

Maps 3.1-7 c to n present the change of potential AEM area of the different AEM. Maps 3.1-7 c and d show the potential area of the measure 'crop rotation of four crops' (NA-2). In the counties in Bessere Rheinebene (e.g. KA) and in the south (RV, LOE) the area of NA-2 increases due to an increase of spring cereals area. Spring cereals area is assumed to represent one culture used in the AEM 'crop rotation of four crops' (NA-2).[35] For the AEM NA-2 this is a limiting activity and the increase of spring cereals allows for the extension of the NA-2 measure. Most of the other counties reduce NA-2 area, because they extent winter wheat area, which represses the other crop groups and thus potential area for the application of NA-2 is reduced.

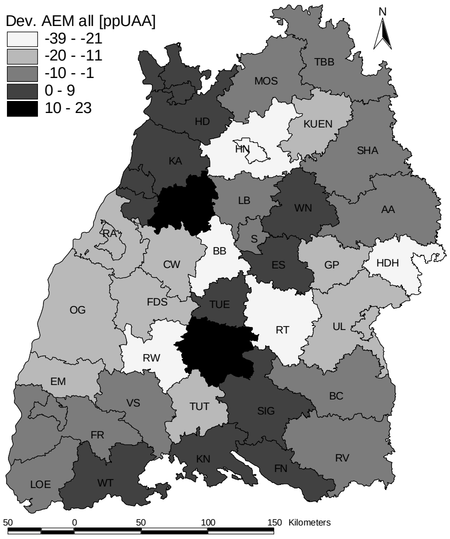
Maps 3.1-7 e to h show the change and the extension of the AEM defined for grassland area: 'extensive grassland with between 0.3 and 2.0 large animal units per ha' (NB-1), 'extensive grassland with between 0.3 and 1.4 large animal units per ha' (NB-2), and 'regional typical meadows' (NC-4) (cf. Section 2.1). In most of the counties, the area of NB-1 is decreased and converted into NB-2 area. Thus, the measure of cattle farming with higher cattle density and intensive grassland is moved to cattle farming with lower cattle density on extensive grassland. The increase of extensive grassland results also in an increase of NC-4 area (Map 3.1-7 i). In few counties grassland with measure NB-2 increases (e.g. RV and LOE). Counties which convert grassland into arable land decrease the extensive grassland and also the area with NB-2 (e.g. counties in the Rheinebene).

The measure 'intercropping on arable land in autumn' (NE-2) (cf. Map 3.1-7 k) is attributed to the area for winter wheat, legumes, winter barley, spring barley, oats, rapeseed, rye. The increase of winter wheat increases also the potential area for the NE-2 measure, mainly in cash crop counties of the northern part and in fodder crop counties in the western part, and to a lesser extend in the grassland counties.

In REF the potential area for 'greening of set-aside area' (NE-3) was highest in the arable land districts and smallest in grassland counties and fodder crops counties with small share of set-aside area. However, in the baseline scenario the potential area for NE-3 is decreased to zero in nearly all counties due to the reduction of set-aside area (cf. Map 3.1-7 n).

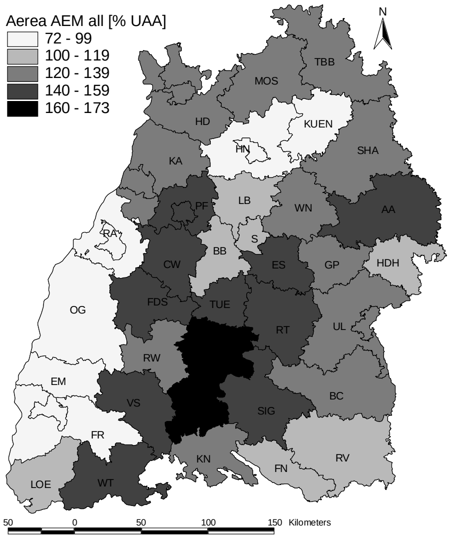
[35] For more details to the calculation of the AEM see Section 3.5.

Map 3.1-7 a: Percentage change of potential total AEM area in CAP2003 compared to REF.



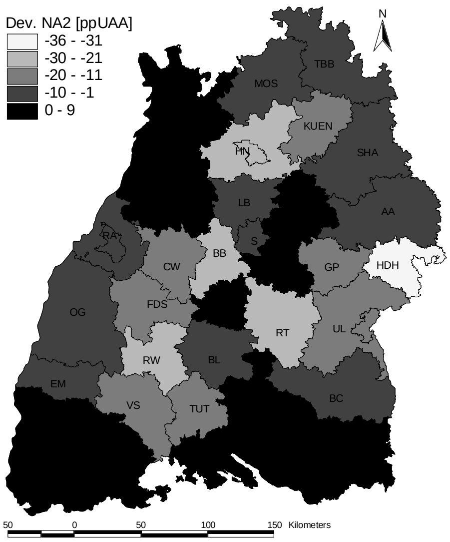
Notes: Unit: pp UAA.

Map 3.1-7 b: Potential total AEM area in CAP2003.



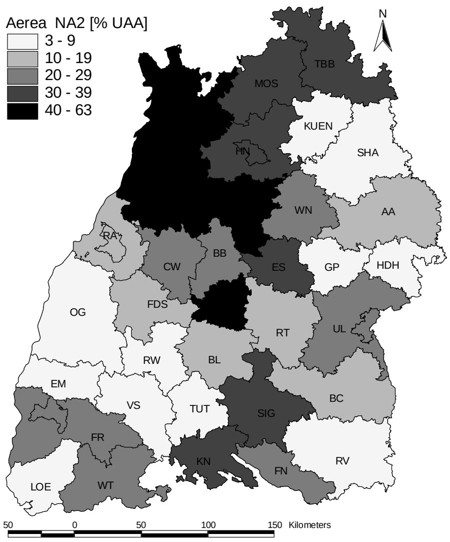
Notes: Unit: % UAA.

Map 3.1-7 c: Percentage change of potential NA-2 area in CAP2003 compared to REF.



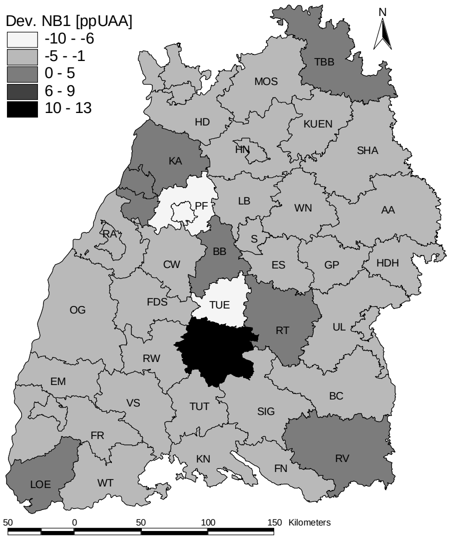
Notes: Unit: pp UAA.

Map 3.1-7 d: Potential NA-2 area in CAP2003.



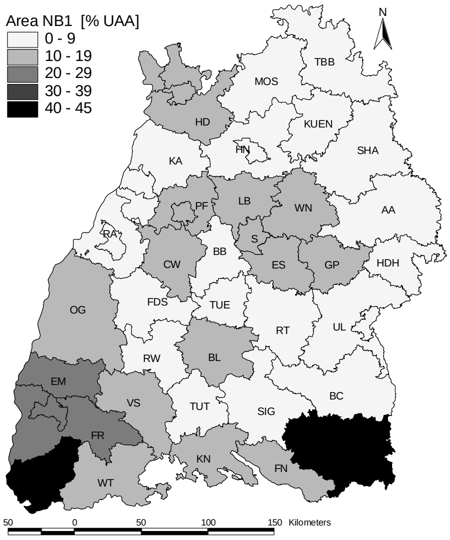
Notes: Unit: % UAA.

Map 3.1-7 e: Change of potential NB-1 area in CAP2003 compared to REF.



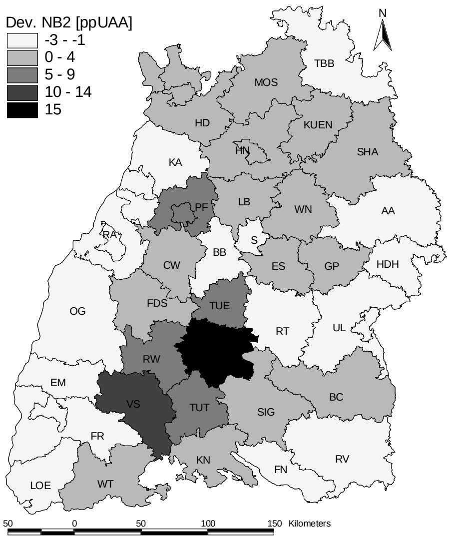
Notes: Unit: pp UAA.

Map 3.1-7 f: Potential NB-1 area in CAP2003.



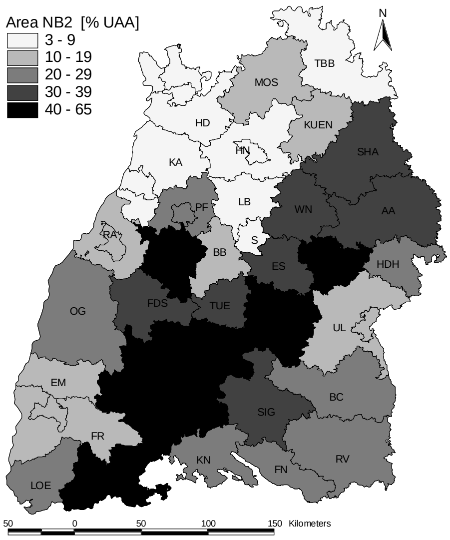
Notes: Unit: % UAA.

Map 3.1-7 g: Change of potential NB-2 area in CAP2003 compared to REF.



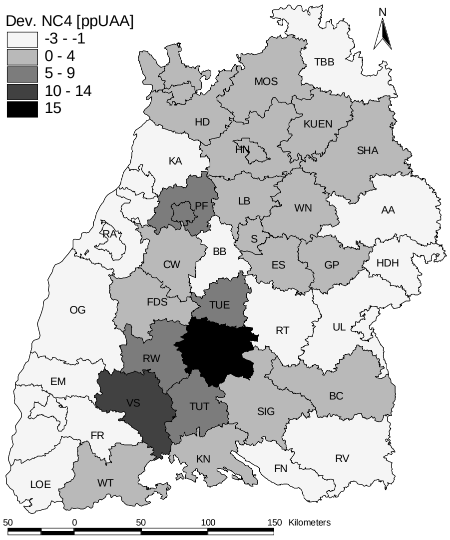
Notes: Unit: pp UAA.

Map 3.1-7 h: Potential NB-2 area in CAP2003.



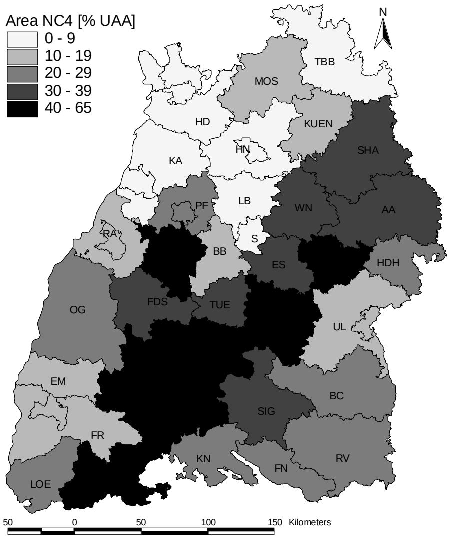
Notes: Unit: % UAA.

Map 3.1-7 i: Change of potential NC-4 area in CAP2003 compared to REF.



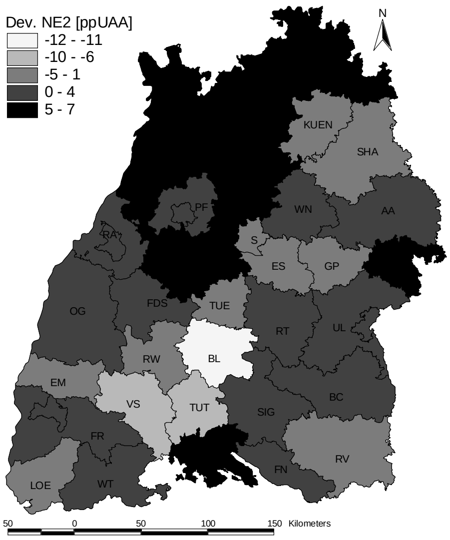
Notes: Unit: pp UAA.

Map 3.1-7 j: Potential NC-4 area in CAP2003.



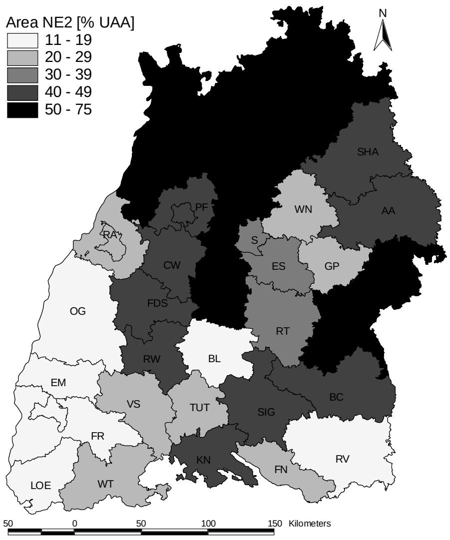
Notes: Unit: % UAA.

Map 3.1-7 k: Change of potential NE-2 area in CAP2003 compared to REF.



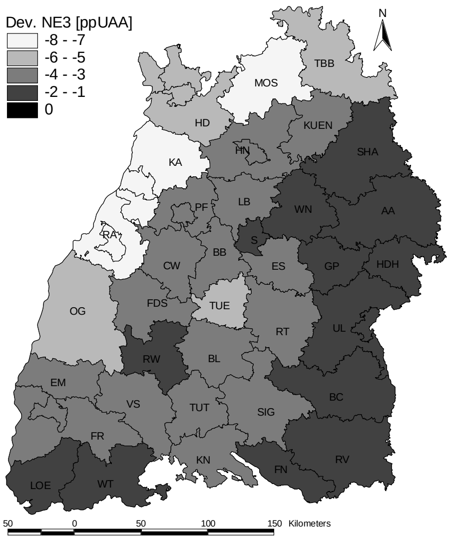
Notes: Unit: pp UAA.

Map 3.1-7 l: Potential NE-2 area in CAP2003.



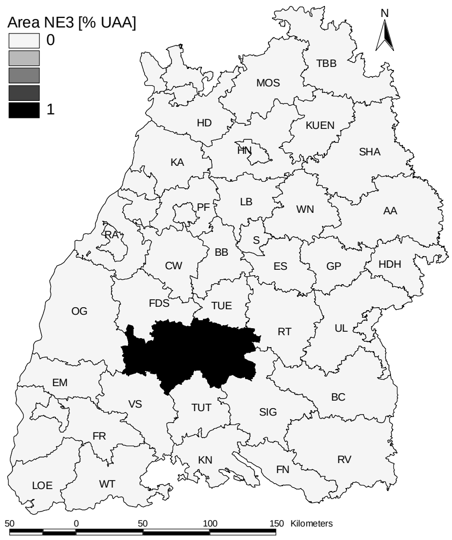
Notes: Unit: % UAA.

Map 3.1-7 l: Potential NE-2 area in CAP2003.



Notes: Unit: pp UAA.

Map 3.1-7 n: Potential NE-3 area in CAP2003.



Notes: Unit: % UAA.

3.1.4 Analysis of indicator values according to farm types

In this subsection the development of the indicator values in the baseline scenario CAP2003 are analysed for all counties aggregated (All) and according to the five farm types (AL-CC, AL-FC, GL-IG, GL-FC and GL-EG) (cf. Table 3.1-9).

Development of economic indicator values

Subsidy volume

In the total study region Baden-Wuerttemberg (BW) the decoupled direct payments from Pillar 1 for UAA result in a significant increase of subsidy volume in comparison to the reference year (+36%). In grassland farm types (i.e. GL-IG, GL-FC and GL-EG) the increase of payments by 67% to 96% is highest, caused by increased payments from Pillar 1 for grassland area. In farm types AL-CC and AL-FC the increase of subsidy volume is with 14% and 21% smaller than in grassland farm types due to only small grassland area. In the complete model region the volume of payments from Pillar 2 increased only slightly because the payments for AEM and compensatory allowances increase slightly in arable land counties and decrease slightly in grassland counties.

Total gross margin

In BW the volume of TGM including subsidies increases by 12%. In AL-CC the increase of total gross margin excluding subsidies is +13%, which is caused mainly by the price and yield increases particularly for cereals. In the same region, TGM including subsidies result in an increase of TGM by +15%, implying that the change of subsidies contributes only by 2% to the increase of TGM.

The differences between the developments of TGM including and TGM excluding subsidies illustrates that in grassland farm types the increased direct payments from Pillar 1 and Pillar 2 are the most important reasons for an increase in agricultural income. In grassland farm types TGM including subsidies increased by +14 to +19%. The TGM excluding subsidies increases only by +6% to +9%. and results from changes in prices, costs and yields.

Development of supply indicator values

Crop production

In BW the biggest changes in crop production area are shown in cereals (+6pp), other crops (-8pp) and conversion of arable land into grassland (+2pp). The decrease of other crops is mainly provoked by decreases in rapeseed and set-aside area. With the latter being reduced due to the abolished obligation of set-aside. The area set free by reduction of set-aside and oilseed area is partially converted to cereals area (e.g. in AL-CC) and to grassland (e.g. in GL-EG). The conversion of arable land into grassland appears particularly in GL-EG.

Crop production intensity and animal production

Intensive crop area increases in BW by 5pp, resulting from conversion of grassland and set-aside to arable land. The changes in variant activity are small and show a slight increase in the farm type AL-CC, where productivity of cash crops are intended to increase by increasing intensive production.

In all farm types production of fattening bulls decreased by -3 to -6% while pig production decreases by -13% to -17%.

Development of environmental indicator values

Nitrogen input

In all farm types the reduction of animal production results in decreases of organic nitrogen. However, the intensification of crop production results in an increase of the mineral nitrogen which increases the indicator total nitrogen by +10%, with the highest increases to be found in the arable farm types (AL-CC, AL-FC) with the most extreme intensification of crop production.

Erosion potential

In BW the erosion potential does not change significantly. However, the farm types GL-IG and GL-EG show considerable changes. In GL-IG the increased maize area and converted grassland increase the erosion potential (+18pp), while in GL-EG the conversion of arable land into grassland and the reduction of other crops decreases the erosion potential (-14pp).

GHG emissions

GHG emissions in BW are decreased only slightly, and is mainly attributable due to reduced bull stocks. In AL-CC an increase due to intensification of crop production is observed, while in GL-FC and GL-EG the reduction of bull stocks result in a decrease of GHG emissions.

Considering the intercropping area, which reduces the effects of nitrate leaching and soil erosion, the development of the indicator values of nitrogen input and erosion potential is decreasing in almost all farm types. Only in GL-IG the erosion potential increases, because here, the area of intercropping is with 5% of UAA too small to reduce the nitrogen and erosion potential.

AEM area

In BW the total area of AEM decreases due to the increase of intensive crop production. The most significant changes appear in arable farm types, where the conversion of grassland into arable land decreases the potential area for AEM applied on grassland.

Table 3.1-9: Indicator values in REF and development of indicator values in CAP2003.

	Unit	Reference year (REF)						CAP2003 scenario (CAP2003)					
	Status in REF/Difference in CAP2003	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]
		EUR ha^{-1}						Change between REF and CAP2003 (%)					
SUBvol[m]	EUR ha^{-1}//%	294	315	249	260	276	288	25	29	41	57	55	36
SUBvol[m] Pillar 1	EUR ha^{-1}/%	245	250	166	159	177	215	14	21	67	96	73	34
SUBvol[m] Pillar 2	EUR ha^{-1}/%	70	91	111	136	134	100	40	18	-29	-20	-7	2
TGM[n] incl. SUB	EUR ha^{-1}/%	1615	1594	1637	1693	1081	1596	15	10	14	15	19	12
TGM[n] excl. SUB	EUR ha^{-1}/%	1321	1279	1388	1433	805	1308	13	6	9	7	6	7
Cereals	%UAA/pp[o]	38	40	11	23	29	33	7	10	2	4	3	6
Maize	%UAA/pp[o]	7	1	16	1	0	4	2	1	5	1	0	1
Fodder crops	%UAA/pp[o]	6	11	4	11	6	8	0	1	0	0	1	0
Others[p]	%UAA/pp[o]	24	15	16	8	11	16	0	0	0	0	0	0
Root crops	%UAA/pp[o]	5	1	1	1	1	2	0	0	0	0	0	0
Oil seeds and legumes	%UAA/pp[o]	7	9	1	4	6	7	-4	-6	-1	-2	-5	-4
Set-aside area	%UAA/pp[o]	4	3	3	2	3	3	-4	-4	-3	-2	-3	-3
Conv. of grassland[q]	%UAA/pp[o]	--	--	--	--	--	--	2	2	3	1	1	2
Conv. of arable land[r]	%UAA/pp[o]	--	--	--	--	--	--	0	0	0	0	5	1
Intensive grassland	%UAA/pp[o]	11	8	33	19	12	14	-2	-2	-1	-2	-1	-1
Extensive grassland	%UAA/pp[o]	14	24	20	37	42	25	1	0	-2	1	5	1
Abandoned UAA[s]	%UAA/pp[o]	--	--	--	--	--	--	0	0	0	0	0	0
Intensive crop area	%UAA/pp[o]	62	55	41	32	33	49	6	7	7	5	2	5
Intensive variant area	%UAA/pp[o]	41	21	42	25	17	29	3	-1	0	0	-1	0
Dairy cows	# ha^{-1} /%[t]	23	38	22	56	34	36	0	0	0	0	0	0
Bulls	# ha^{-1} /%[t]	6	10	8	11	7	8	-5	-5	-6	-4	-3	-4
Fattening pigs	# ha^{-1} /%[t]	209	323	99	147	125	225	-15	-13	-13	-13	-17	-14
Nitrogen total	kg ha^{-1}/ %	198	224	161	203	167	203	12	12	10	8	7	10
Nitrogen total (weight.)[u]	kg ha^{-1}/ %	--	--	--	--	--	--	-1	-6	7	-1	-4	-3
Nitrogen organic	kg ha^{-1}/ %	67	98	72	112	82	90	-7	-6	-7	-4	-7	-6
Nitrogen demand	kg ha^{-1}/ %	133	124	96	91	86	114	23	29	24	23	18	24
Erosion potential	%pot/%[v]	9	7	8	5	4	7	5	-2	18	1	-14	2
Erosion pot. (weight.)[u]	%pot/%[v]	--	--	--	--	--	--	-8	-19	14	-7	-23	-10
GHG[w] emissions	kg ha^{-1}/%	1551	2205	1506	2647	1751	2014	4	1	1	-5	-4	-1
Potential AEM area[x]	%UAA/pp[o]	122	142	96	140	161	120	-7	-10	-6	-2	-9	6

a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percent share of UAA/percentage points of UAA compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare/difference in percent. u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. v: Potential in percent of uncovered arable land/difference in percent. w: Green house gas. x: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity.

3.1.5 Analysis of results according to achievement of policy objectives

This sub-section analyses the observed developments of the indicator values between the status quo in scenario REF (in the year 2000) and the scenario CAP2003 (in the year 2015).

The impact on the policy objectives is concluded according to the framework described in Section 2.1.[36]

The thresholds for positive, more positive and extremely positive development of the farm types, with regard to specific policy objectives, are defined for changes of greater or equal +5% (or pp), +10% (or pp) and +15% (or pp). For indicator values with more extreme changes (as e.g. the change of subsidy volume or TGM) the attribution of positive and negative changes is derived according to respective size of the values. Table 3.1-11 summarizes the observed developments of indicator values and their impact on the policy objectives.

Economic objectives

Reduction of subsidies

In the baseline scenario the direct payments from Pillar 1 are increased which negatively impacts the policy objective of subsidy reduction in the study region. The changes in subsidy volume affect the farm types differently, resulting in different average payments. Counties with higher shares of grassland show a bigger increase in subsidy volume than counties with smaller shares of grassland. Additionally, with minor effect, the reference value of subsidies is smaller for grassland farm types, which is why the percentage change appears to be more extreme.

While payments from Pillar 1 are increased in all farm types, the payments from Pillar 2 keep constant in the complete model region, however they show decreases in the grassland farm types.

Income stability

The farm income including subsidies develops positively in all farm types. Losses due to reduced subsidies for crop area and livestock are compensated mainly due to high increases of agricultural prices in all farm types, particularly in AL-CC. Thus, small losses of a maximum 5% appear in only few counties. In counties with a high share of cereals production the increase in cereal yields and producer prices result in a high increase of TGM. Counties with small grassland shares and relatively high share of fodder crops area show the smallest

[36] The comparison of results between the status quo of REF in the year 2000 and the baseline scenario CAP2003 (15 years later in the year 2015) implies that additionally to the changes in policies, the development of prices, costs and yields are considered in the analysis. The analysis of only policy driven impacts in CAP2003 would require a comparison between CAP2003 and a scenario in which the policy of REF continues and the prices, costs and yields are developed up to the year 2015.

increase of TGM. Due to their small area of cash crops they do not profit significantly from the increases in cereals yields and producer prices. The objective of income stabilization seems to be reached in the baseline scenario. Even, without CAP payments most of the counties are able to keep their income at least on the level of the year 2000 (cf. Map 3.1-2 b).

Table 3.1-10 shows the average TGM and the average subsidies per farm type. The differences in total subsidy volume result from a combined effect of differences in payments from Pillar 1 and Pillar 2 in the farm types. The differences of payments from Pillar 1 are caused by different shares of crops which are entitled to additional payments (e.g. oilseeds) or are not entitled for the harmonized payments (e.g. wine and fruit, see Section 3.1, Map 3.1-1 d). Since the CAP Health Check 2008 also wine and fruit area are entitled to the harmonized direct payments, and additional payments for energy crops (paid for oilseeds) are removed. Nevertheless, the payments from Pillar 1 differently considered for oilseeds, wine and fruit in the baseline scenario should not result in big differences for the average payments. The average payments from Pillar 1 in the farm types and in the counties can be regarded as being approximately equally at 302 EUR ha^{-1}.

The difference in payments from Pillar 2 is caused by higher compensatory allowance and higher AEM payments for grassland than for arable land. Thus, farm types with a higher share of extensive grassland (AL-FC and GL-EG) receive the highest average payments from Pillar 2.

The share of subsidies in income is on average for BW 22% and reaches from 33% in GL-EG to 19% in GL-IG. This indicates that subsidies are more important for the extensive counties. However, with only 40% the subsidies count not even for the half of the income.

Distribution of subsidies and income

The distribution of income and subsidies is similar in the farm types as observed in the NUTS3 counties. The mean values of the average payments of all counties are used to represent a benchmark of a mean income for BW. This benchmark should be reached by all farm types in order to result in an equal distribution of income. In order to indicate the distribution of subsidies and income in the baseline scenario the benchmark is set to 100% and the percentage deviations are compared. The subsidy volume of the intensive farm types AL-CC (94%) and GL-IG (90%) are smaller than the mean value of all counties in BW (100%). In AL-FC the subsidy volume nearly reaches with 98% the mean of the average total gross margin. This farm type seems to receive direct payments in a size big enough to reach the average income. The intensive farm types AL-CC and GL-IG receive less direct payments compared to the other farm types, but show with 104% higher average income than the average. This implies that in intensive farm types the smaller payments are still big enough to reach the mean income. Also GL-FC receives with 109% more than the mean income. Thus, in these farm types a potential reduction of direct payments might result in an income distribution closer to the mean income. In the extensive farm types GL-EG average direct payments of 109% are higher than the mean payments but these farm types just reach 72% of the mean income. Here an increase of direct payments would be necessary to reach the mean income.

Table 3.1-10: Average subsidy volume and total gross margin in CAP2003 according to farm types

	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]
	EUR ha^{-1}						% of BW average					
SUB[m] volume	368	406	351	408	428	392	94	104	90	104	109	100
SUB[m] volume Pillar 1	279	303	277	312	306	288	97	105	96	108	106	100
SUB[m] volume Pillar 2	98	107	79	109	125	102	96	105	77	107	122	100
TGM[n] volume incl. SUB	1857	1753	1866	1947	1286	1788	104	98	104	109	72	100
TGM[n] volume excl. SUB	1493	1356	1513	1533	853	1400	107	97	108	110	61	100
Share of SUB of TGM incl. SUB	20%	23%	19%	21%	33%	22%						
Compensatetion							O	C	O	O	U	

a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated.
Notes: O: Overcompensation of income losses, the income is greater than the mean income. U: Undercompensation of income losses, the income is smaller than the mean income. C: Compensation, the income losses are compensated; the income is as large as the mean income is.

Supply objectives

Food production and retaining of UAA

Supply in terms of crop production is stabilized for the complete model region and positively influenced for cereals production particularly in AL-CC and AL-FC. The group of "other crops" is negatively affected due to decreases in oilseeds, legume and set-aside area. In the extensive farm type GL-EG the extent of arable area is negatively influenced due to the conversion of arable land into extensive grassland, which itself is a positive development for extensification of grassland. With respect to the intensification of crop production the development is decreasing for intensive crop area and not changed for intensive production variants. Smallest influences are found in the grassland farm types. In all farm types livestock production is negatively influenced for bulls and pig production.

CAP 2003 reform reaches the supply sub-objective of retaining UAA in good agricultural and environmental condition. Instead of arable or grassland falling out of production as abandoned area it is converted into extensive grassland (in GL-EG). However, the use of UAA as extensive grassland indicates a less intensive use for production, i.e. a decrease in intensive production is indicated.

Environmental objectives

Environmental pollution and AEM area

While the development of the environmental indicator of organic nitrogen is decreasing, the total nitrogen demand and the complete nitrogen input increased the risk of nitrogen leaching in all farm types, particularly in the arable farm types. On average the weighted erosion potential develops positive in the study region BW but shows negative developments in AL-CC and GL-IG. GHG emissions do not change significantly in the complete study region, showing a positive change only in GL-FC.

The development of AEM area is negative in BW as well as in all farm types, with the exception of GL-FC where no change occurs. Generally the environmental indicator values develop regionally negatively and environmental pressure increases in the CAP2003 scenario.

Table 3.1-11: Indicator values in REF and impact on policy objectives in CAP2003.

		Reference year (REF)						CAP scenario (CAP2003)					
	REF/CAP	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]
SUBvol[m]	[%]	294	315	249	260	276	288	-	-	- -	- - -	- - -	- -
SUBvol[m] Pillar 1	[%]	245	250	166	159	177	215	-	-	- -	- - -	- -	- -
SUBvol[m] Pillar 2	[%]	70	91	111	136	134	100	- - -	- -	+ +	+ +	+	-
TGM[n] volume incl. SUB	[%]	1615	1594	1637	1693	1081	1596	++	+	++	++	+++	+
TGM[n] volume excl. SUB	[%]	1321	1279	1388	1433	805	1308	+++	+	++	+	+	+
Cereals	[%]/[pp][o]	38	40	11	23	29	33	+	++	0	0	0	+
Maize	[%]/[pp][o]	7	1	16	1	0	4	0	0	+	0	0	0
Fodder crops	[%]/[pp][o]	6	11	4	11	6	8	0	0	0	0	0	0
Others[p]	[%]/[pp][o]	24	15	16	8	11	16	-	- -	0	0	-	-
Root crops	[%]/[pp][o]	5	1	1	1	1	2	0	0	0	0	0	0
Oil seeds and legumes	[%]/[pp][o]	7	9	1	4	6	7	-	-	0	0	-	0
Set-aside area	[%]/[pp][o]	4	3	3	2	3	3	0	0	0	0	0	0
Conv. of grassland[q]	[%]/[pp][o]	--	--	--	--	--	--	0	0	0	0	0	0
Conv. of arable land[r]	[%]/[pp][o]	--	--	--	--	--	--	0	0	0	0	-	0
Intensive grassland	[%]/[pp][o]	11	8	33	19	12	14	0	0	0	0	0	0
Extensive grassland	[%]/[pp][o]	14	24	20	37	42	25	0	0	0	0	+	0
Abandoned UAA[s]	[%]/[pp][o]	--	--	--	--	--	--	0	0	0	0	0	0
Intensive crop area	[%]/[pp][o]	62	55	41	32	33	49	-	-	-	-	0	-
Intensive variant area	[%]/[pp][o]	41	21	42	25	17	29	0	0	0	0	0	0
Dairy cows	[%]	23	38	22	56	34	36	0	0	0	0	0	0
Bulls	[%]	6	10	8	11	7	8	-	-	-	0	0	0
Fattening pigs	[%]	209	323	99	147	125	225	- - -	- -	- -	- -	- - -	- -
Nitrogen total	[%]	198	224	161	203	167	203	- -	- -	- -	-	-	- -
Nitrogen total (weight.)[t]	[%]	--	--	--	--	--	--	0	+	-	0	0	0
Nitrogen organic	[%]	67	98	72	112	82	90	+	+	+	0	+	+
Nitrogen demand	[%]	133	124	96	91	86	114	- -	- -	- -	- -	- -	- -
Erosion potential	[%]/[pp][u]	9	7	8	5	4	7	- -	0	- - -	0	+ +	0
Erosion pot. (weight.)[t]	[%]/[pp][u]	--	--	--	--	--	--	+	+++	- -	+	+++	+ +
GHG[v] emissions	[%]	1551	2205	1506	2647	1751	2014	0	0	0	+	0	0
Potential AEM area[w]	[%]/[pp][o]	121	120	86	129	154	122	-	- -	-	0	-	- -

a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percentage points of utilized agricultural area compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. u: Percentage points difference from reference year. v: Green house gas. w: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity.
+ small positive impact on objective, ++ medium positive impact on objective, +++ highest positive impact on objective
- small negative impact on objective, - - medium positive impact on objective, - - - highest positive impact on objective, 0: no impact on objective

3.1.6 Scenario discussion

In this subsection the results of the baseline scenario are compared with results of other agricultural policy studies.

Segger (2005) describes the impact of the CAP 2003 reform on the income for five different "example farms" in Baden-Wuerttemberg. These example farms represent specific individual dairy farms with different specialization in dairy feeding, and they allow for a comparison with the farm types as defined in this study (cf. Section 2.2), as all farm types in this study consider dairy production. Table 3.1-12 shows the production data of the example farms as given in Segger (2005) and the average data values of the farm types as given in the study at hand. The Segger study categorizes 5 "example farms" according to the following attributes: the total hectares of UAA, the share of grassland of UAA, the dairy cow density and the milk yield. A ranking of the attributed values of the production data makes it possible to compare the results of the example farms in Segger (2005) with the results of the farm types of ACRE. A direct comparison of absolute values is not possible because example farms are based on farm level data and farm types are based on NUTS3 county data.[37]

According to the ranking the example farms 'farm showing a large share of fodder maize' is compared with AL-FC, 'grassland farm in less favoured areas' is compared with GL-FC and 'very extensive grassland farm' are compared with the farm types is compared with GL-EG. The example farms 'mixed farms' and 'intensive grassland farm' are compared with the farm types AL-CC and GL-IG, according to the specification of animal and crop production in the farm types (cf. Section 2.1). The ranking does not match well because the farm types derived from NUTS3 data are more diversified in production than the example farms based on single farms. The farm types GL-IG and AL-CC have beside the high shares of intensive grassland partially also shares of arable land with special crop production (e.g. counties in the VGG Rheinebene and Stuttgart, cf. Section 2.1). This results in smaller cow density and smaller share of grassland for the NUTS3 based farm types than in the example farms.

Table 3.1-12 presents the compared example farms and the farm types, their attributes and results both as values and the rank according to the value of the production data. The comparison indicates that the income development calculated in this study is consistent with the values published by Segger (2005) for most of the farm types. Income development with rank 5 is the highest for the 'very extensive grassland farm' and GL-EG, while it is lowest with rank 2 for 'farm with large share of fodder maize' and AL-FC.

[37] In order to rank the production data of the 5 example farms in Segger (2005) and the 5 farm types in this study the highest value of each production value is attributed with the rank 5. The lowest is value is ranked with 1. In case of equal values of production data the attributes are ranked with the same rank.

Table 3.1-12: Comparison of indicator values and ranks of example farms in Segger (2005) and ACRE farm types.

		Very extensive grassland farm	GL-EG	Grassland farm in les favoured areas	GL-FC	Intensive grassland farm	GL-IG	Farm with large share of fodder maize	AL-FC	Mixed farm	AL-CC
		Comparison of indicator values									
Share of grassland	[% UAA]	100	53	100	57	90	52	25	33	50	25
Cow density	[heads 100 ha^{-1}]	67	34	75	56	109	22	75	38	75	23
Dairy yield	[kg cow^{-1}]	5000	4649	6500	5029	8000	4409	8000	5119	6500	4783
Development of TGM	**EUR and %[a]**	**3705**	**19**	**500**	**15**	**-2500**	**14**	**-4248**	**10**	**-2500**	**15**
		Comparison of ranks									
Share of grassland	rank	5	4	5	5	4	3	2	2	3	1
Cow density	rank	3	3	4	5	5	1	4	4	4	2
Dairy yield	rank	3	2	4	4	5	1	5	5	4	3
Development of TGM	rank	**5**	**5**	**4**	**4**	**3**	**3**	**2**	**2**	**3**	**4**

a) in terms of EUR per 100.000 kg milk quota for the example farms as given in Segger (2005), in terms of percentage increase for the ACRE farm types

The comparison with results of the baseline scenario illustrates that the results of income development in the farm types of the study at hand are in line with the study of Segger (2005). The development of income for the farm types as given in ACRE corresponds with the development of income of comparable example farms in Segger (2005).

Discussion of the results according to achievement of policy objectives

In the following simulated results are compared and discussed with the impacts expected in other studies published for policy decision support (SABAP 2005, Bureau et al. 2007, SABAP 2010) with respect to the impacts on the achievement of policy objectives as defined for the CAP 2003 reform.

Reduction of subsidies

The results of this study illustrate that the subsidy volume increased by an overall of 36%, indicating a high increase of public expenditures. Within the EU budget the expenditure of the CAP is the largest, comprising more than one third of the entire EU budget. Bureau et al. (2007: 4) assume that higher benefits would result from spending more money in other policies than the CAP, such as research, technology and infrastructure. Therefore, future policy instruments should be oriented towards a reduction of expenditures of CAP payments, and money saved should be spend in policy measures that are more in line with the Lisbon Agenda (cf. Subsection 2.1.1, Bureau et al., 2007). However, the baseline scenario results indicate that the CAP 2003 reform tends to an increase in subsidies and not in a subsidy reduction as officially stated and aimed at.

Income stabilisation

Farm income is increased in the overall study region BW and most of the NUTS3 counties manage to keep the income level of the reference year even without the modified direct payments (cf. Map 3.1-1 a). This income increase/stabilization results from assumed increases in prices and yields (see Map 3.1-2 c). However, according to Bureau et al. (2007: 4) a compensation of income losses (arising from policy changes) can actually not be justified when agricultural income is still ensured due to increased agricultural market prices.

On the other hand, it has to be mentioned that the increases of agricultural prices as assumed in this study have to be considered as extremely high (cf. Subsection 3.1.1.) and thus the increase of income resulting from increased prices might be overestimated.

The transfer of subsidies to higher land renting prices is another reason why it is assumed that the agricultural income would not change due to reduction of subsidies. SABAP (2010) describes that direct payments are partially transferred to the land renting prices and so not contributing to the farmers' income but to the land owner. Thus, a reduction or abolishing of direct payments would decrease the prices for land renting and such a reduction could then balance farm income losses due to subsidy reductions (SABAP 2010: 7). However, such an effect could not be simulated in this study as the land markets are not considered in the model.

Adaption of direct payments

Simulated results for regional farms and for farm types illustrate unequal developments in the levels of subsidies and incomes in NUTS3 counties, indicating that the CAP 2003 reform has unequal distributional effect (cf. Subsection 3.1.3). Former CAP reforms (MacSharry reform, Agenda 2000) also resulted in unequal distributional effects, i.e. the situation seems not to be improved by the CAP 2003 reform. An additional distributional effect is often pointed out at farm level, stating that larger farms[38] in more fertile areas receive higher payments than smaller farms and farms in less favoured areas (Bureau et al. 2007: 4, SABAP 2005: 4). However, as this study does not conduct the analysis at farm level such an effect cannot be shown directly.

[38] This study does not take farm size into account, because the regional farm approach does not consider single farms. A possibility to consider would be to use regional statistical data of farm holdings to detect correlations between farm size and distributive effect

On average in Europe the share of subsidies is estimated to be about 50% of the farm income. However, this does not mean that a sufficient high income is not possible without subsidies (SABAP 2010: 7). The study at hand calculates for the farm types that the share of subsidies in income ranges from 19% to 30% (cf. Subsection 3.1.5). This would mean for the study region that the share of subsidies in income is lower than the average and that farm income is less depending on subsidies.

The rationale for direct payments in the EU is mainly the compensation of income losses arising due to reforms in agricultural policy. However, the policy changes were more rigorous in the MacSharry reform 1992 and in the Agenda 2000 than in the CAP reform of 2003 (cf. Section 1.1; Bureau et al, 2007: 4). Nevertheless the basis for calculation and justification for compensation payments is still related to the earlier reforms which took place several years ago, even though the justification for compensation is losing its meaning in the long term (Bureau et al. 2007: 4, Fellmann 2007: 144ff, SABAP 2005: 7). Against this background Bureau et al. (2007: 4) argue that it is difficult to explain to European taxpayers that agricultural production is still entitled to high direct payments. On the contrary, a payment system which is oriented towards the remuneration of positive external effects of agricultural production in terms of environmental services and landscape protection might be better justifiable (SABAP 2005: 8). To cope with this issue the direct payments could be modified e.g. by reduction of the payments from Pillar 1 to a basic sum and expansion of payments from Pillar 2 (SABAP 2005: 8).[39] The analysis in Subsection 3.1.5 confirms that for some farms types the payment of high subsidies may not be justified because the direct payments already overcompensate a mean income (cf. Table 3.1-10).

Production intensity and environmental pressure

On the one hand the simulation results show an increase and intensification of cereals production and agricultural production is intensified by converting grassland into arable land in most of the counties (cf. Map 3.1-3 j). On the other hand, in counties with large share of extensive UAA, arable area is converted into grassland instead of falling abandoned (cf. Map 3.1-3 k). While the former implies an intensification, the latter implies an extensification and thus a decrease of environmental pressure due to agricultural production. Increased production of cereals and avoiding abandoning of UAA correspond to the stated objectives of the CAP 2003 reform (cf. Section 2.1).

[39] In Subsection 3.2 scenario calculations are presented with corresponding modification of the direct payments.

The increased crop production intensity in the counties and in farm types results in increasing environmental pressure. Such an increase in environmental pressure as a direct effect of the CAP 2003 reform is also expected by Bureau et al. (2007: 4), and hence should be addressed by future CAP reforms. On the contrary, an increase of agricultural production and production intensity is expected to become necessary due to an increase of demand for agricultural products (Bureau et al. 2007: 5). However, the results of this study raise the question if the policy instruments of the CAP 2003 reform are appropriate to address such a need for increased productivity. The instruments of the CAP 2003 reform as simulated in this study do not seem to be appropriate to avoid the effect of higher environmental pressure in the region with intensified production and to avoid the reduction of intensity in extensive regions.
Besides the increase in agricultural production for food, the future CAP will also be faced with increased production of energy crops (Bureau et al. 2007: 2). Energy crop production will result in an additional environmental pressure and in an extension of intensive production in extensive areas. In this baseline scenario energy crop production is not simulated but the impact on the policy objectives under production of energy crops is addressed in Section 3.3.

Concluding remarks

The results of the baseline scenario indicate similar impacts on economic, supply and environmental policy objectives as also projected in other policy studies. The subsidy volume increases even though it was actually aimed at to be decreased and modified in order to avoid unwanted distributional income effects. Increase of crop production intensity potentially raises environmental pressure especially in intensive production regions. On the other hand, in extensive regions the production area is retained as grassland and production intensity tends to decrease. It has to be mentioned that the production intensity might also be increased in extensive areas due to energy crop production, however this is not considered in the baseline scenario.

3.2 Subsidy reduction scenarios

In the subsidy reduction scenarios the amount and use of direct payments is modified in order to reduce the volume of subsidy. Two scenarios are simulated: one in which the direct payments of Pillar 1 are reduced and a second in which the payments of Pillar 1 are reduced but the money saved is used to increase payment of Pillar 2. In the following subsections first the scenario background is described (Subsection 3.2.1), followed by the scenario assumptions (Subsection 3.2.2). The modelling of the scenario is described in Subsection 3.2.3. Subsection 3.2.4 presents the analysis of the results according to NUTS3 counties and Subsection 3.2.5 according to farm types. A scenario discussion follows in Subsection 3.2.6.

3.2.1 Scenario background

The analysis of the simulation results of the baseline scenario (cf. Section 3.1) reveals that the effects of direct payments paid according to the CAP 2003 reform help to achieve the policy objectives of income stabilization and food supply. However, a modification of direct payments in order to reduce and to adapt them is necessary due to the following reasons (cf. Section 3.1, SABAP 2005, Bureau et al. 2007, SABAP 2010):

- reduction of budget costs,
- inefficiencies as instrument for income stabilisation,
- negative distributional effects,
- fading justification;
- compliance with future WTO commitments,
- uneven benefits across MS,
- reducing the environmental pressure of agricultural production.

There are plenty of proposals in the literature provided on how the use of direct payments in the CAP should be modified (e.g. SABAP 2005, Swinbank and Trantner 2004, Bureau et al. 2007, Fellmann 2007, Bureau and Mahe 2008). Among others also the SABAP (2005) proposed that the existing direct payments scheme should be phased out and be replaced by a basic flat rate payment, either paid from Pillar 1 or Pillar 2. Furthermore, the SABAP proposes an expansion of direct payments from Pillar 2 (SABAP 2005: 10). These two proposals have been taken as basis for running the following two policy scenarios:

Reduction of subsidies (SUBred): Simulation of a basic flat rate payment anchored in Pillar 1, without extension of payments from Pillar 2.
Shifting of subsidies from Pillar 1 to Pillar 2 (SUBshift): Simulation of a basic flat rate payment anchored in Pillar 1 and Pillar 2, implying shifting money from Pillar 1 to Pillar 2.

3.2.2 Scenario assumptions

The two agricultural policy scenarios conducted in this subsection are (1) the "SUBred" scenario, where the direct payments from Pillar 1 are reduced by an equal percentage rate per hectare and remaining money is paid as flat rate and (2) the "SUBshift" scenario, where direct payments form Pillar 1 are reduced by an equal percentage rate for per hectare and the amount of money saved by reductions in Pillar 1 payments is shifted to payments of Pillar 2.[40] The assumptions of both scenarios are summarized in Table 3.2-1.
In the SUBred scenario the direct payments in Pillar 1 are modelled by reduced decoupled payment entitlements paid as a flat rate payment for each hectare of utilized agricultural area (UAA). Pillar 2 is modelled by payments for the application of agro-environmental measures (AEM), defined in the model as payments for intensive grassland production, extensive grassland production, intercropping on arable land and compensatory allowance.

Table 3.2-1: Main assumptions on direct payments in the SUBred and SUBshift scenarios, final status in the year 2020.

		BL **Baseline scenario**	**SUBred** **Reduced subsidies scenario**	**SUBshift** **Shifted subsidies scenario**
Pillar 1	Decoupled payments for UAA	PE^{BL} = 302 EUR ha^{-1}	PE^{SUBred} = PE^{BL} – (PE^{BL} * %RED)	$PE^{SUBshift}$ = PE^{BL} – (PE^{BL} * %RED)
Pillar 2	Payments for AEM	AEM^{BL} = depending on measure	AEM^{BL} = depending on measure	$AEM^{SUBshift}$ = AEM^{BL} + *W* * (PE^{BL} * %RED)

PE^{BL} : Decoupled payment entitlements, direct payments in baseline scenario. %RED: Percentage reduction factor
AEM^{BL}: Payments for agro-environmental measures in baseline scenario. $PE^{SUBshift}$: Decoupled payment entitlements, direct payments in SUBshift scenario. $AEM^{SUBshift}$: Payments for agro-environmental measures in SUBshift scenario
W: weighting factor according to the size of payments for the measures, according to MEKA3 (Marktentlastungs- und Kulturlandschaftsausgleich) in Baden-Wuerttemberg

According to $W_{measure\,X} = AEM^{CAP}_{measure\,X} * \left(\sum_{meaure\,N}^{measure1} AEM^{CAP}_{measure} \right)^{-1}$ and $\sum_{measure\,N}^{measure1} W_{measure} = 1$

[40] The Subsection 3.2.2 draws on Henseler et al. (2008).

In the SUBshift scenario direct payments from Pillar 1 are reduced and partially shifted to Pillar 2, i.e. Pillar 2 is strengthened. This is modelled by (1) a reduction of total expenditures for agricultural policy through a reduction of the total payment amount with, (2) a shift of payments from Pillar 1 to Pillar 2 while there is (3) no change in the relative importance of the different environmental measures of Pillar 2. The direct payments from Pillar 1 are modified in a way that the regional payment entitlements are reduced by a percentage magnitude. The amount subtracted is partially attributed to payments for the modelled AEM of the regional environmental programs. The share of payments to the different AEM reflects a weighting of the original payments in environmental programs. This means, for example, that the payment from Pillar 1 for one hectare of UAA (PE^{CAP}) is reduced by 70%. The monetary amount of 70% that is thereby deducted is not fully redistributed to the modelled AEM of environmental programs. Instead, only a weighted share of the 70% is used for this purpose. Thus, the total volume of the subsidies paid is reduced.

Table 3.2-2 presents the calculation of regional payments for an example district with a LVZ (yield measure index) of 30 and where the four AEM are applied that are defined in the model (intensive grassland, extensive grassland, intercropping and compensatory allowance for grassland and arable land) For example intensive grassland receives in the baseline scenario 302 EUR ha^{-1} from Pillar 1 and 90 EUR ha^{-1} from Pillar 2, resulting in a total of 392 EUR ha^{-1}. In SUBshift, the payments from Pillar 1 are reduced to 30%, which is 90.6 EUR ha^{-1}. This sets free an amount of 211.4 EUR ha^{-1} (represented in Table 2 by SUBshift minus CAP, or -211.4 EUR ha^{-1}) and this deducted money is redistributed partially to payments of Pillar 2 for agri-environmental programs. The money is redistributed to the single AEM by using a weighting according to the payments from Pillar 2. For instance the weighting for the AEM for intensive grassland is 22% because the payment of 90 EUR ha^{-1} represents 22% of the sum paid for all agri-environmental measures (90 EUR ha^{-1} for intensive grassland +130 EUR ha^{-1} for extensive grassland +110 EUR ha^{-1} for intercropping + 25 EUR ha^{-1} for compensatory allowance on arable land +50 EUR ha^{-1} for compensatory allowance on grassland and forage = 405 EUR ha^{-1}). The weighting of 22% is used to calculate the payments for the AEM intensive grassland from the money saved from Pillar 1 (i.e. 211.4 EUR ha^{-1}), i.e. 22% * 211.4 EUR ha^{-1} = 47 EUR ha. This amount of 47 EUR ha^{-1} is added to the original 90 EUR ha^{-1}. The resulting total payment of Pillar 1 and Pillar 2 in the SUBshift scenario is 228 EUR ha^{-1}, which is 164 EUR ha^{-1} less (or -70%) than the CAP payments of 392 EUR ha^{-1} in the baseline scenario.

Table 3.2-2: Calculation of payments of Pillar 1 and Pillar 2 in CAP2003 and SUBshift scenarios.

Payments	Weight of measure *W* b)	CAP2003 baseline	Transferred from Pillar 1 to Pillar 2 EUR ha^{-1} or %	SUBshift	Difference SUBshift – CAP EUR ha^{-1}
Intensive grassland					
Pillar 1		302		302 - (70% * 302) = 90.6	90.6 – 302 = -211.4
Pillar 2	22%	90	22% * 211.4 = 47	90 + 47 = 137	137 – 90 = 47
Total		392		228	228 – 392 = –164
Extensive grassland					
Pillar 1		302		302 - (70% * 302) = 90.6	90.6 – 302 = -211.4
Pillar 2	32%	130	32% *211.4 = 68	130 + 68 = 198	198 – 130 = 68
Total		432		288	288 – 432 = –143
Intercropping					
Pillar 1		--	--	--	--
Pillar 2	27%	110	27% * 211.4 = 57	110 + 57 = 167	167 – 110 = 57
Total		110		167	57
Compensatory allowance arable land (LVZ > 30)					
Pillar 1		--	--	--	--
Pillar 2	6%	25	6% *211.4 = 13	25 + 13 = 38	38 – 25 = 13
Total		25		38	13
Compensatory allowance grassland and clover (LVZ > 30)					
Pillar 1		--	--	--	--
Pillar 2	12%	50	12% * 211.4 = 26	50 + 26 = 76	76 – 50 = 26
Total		50		76	26

Notes: - -: no data. Example: for the 5AEM payments of the environmental program in a NUTS3 county with LVZ > 30.

3.2.3 Scenario modelling

A sensitivity analysis has been conducted in order to find the scale for reducing and shifting direct payments. Via the sensitivity analysis benchmarks for modification of direct payments are defined in a way that allows the simulation of a policy which aims at the objective of subsidy reduction but at the same time also at the objectives of farm income stabilization and ensuring of agricultural supply (cf. Section 2.1). Thus the direct payments from Pillar 1 and Pillar 2 have been modified in a way that for the complete model region Baden-Wuerttemberg (1) a significant reduction of subsidies is reached (2) the agricultural income level is retained as close as possible to the level of the reference year and (3) that as few area of UAA as possible (less then 10% of UAA) falls abandoned.

Table 3.2-3 presents selected results of the sensitivity analysis for the scenarios SUBshift and SUBred. To identify which scenarios achieve simultaneously the objectives of subsidy reduction, income stabilization and retaining of UAA the changes of the three indicator values of subsidy volume, total gross margin and abandoned UAA are analysed. For the scenario SUBred the level of reduction of payments from Pillar 1 by 60% is selected as the level optimizing the achievement of all three objectives (this scenario is named as SUBred60%). For the scenario SUBshift the level of shifting 70% of payments from Pillar 1 to Pillar 2 is selected as the level optimizing the achievement of all three objectives (this scenario is named as SUBshift70%).

The reduction of subsidy volume is for both scenarios in a comparable range with -32% in SUBred60% and -33% in SUBshift70%. Both selected scenarios show no or only a slight decrease in total gross margin and an abandoning of UAA in an acceptable range by less than 10% of UAA. The other levels of subsidy reduction tested in the sensitivity analysis show either a lower level of reduction of subsidies or a larger share of abandoned UAA.

Table 3.2-3: Changes of indicator values under variation of direct payments in the model region in comparison to the reference year (REF).

Scenario[a]	Reduction, shifting	Subsidy volume [%]	TGM[b] volume [%]	Abandoned UAA[c] [pp]	Evaluation for being selected or not as scenario
SUBred50%	50%	-22	2	6	subsidy reduction not enough
SUBred60%	60%	-32	1	7	selected scenario
SUBred70%	70%	-44	-2	12	share of abandoned UAA too large
SUBshift60%	60%	-17	3	5	subsidy reduction not enough
SUBshift70%	70%	-33	0	9	selected scenario
SUBshift80%	80%	-47	-2	12	share of abandoned UAA too large

Notes: SUBred50%: scenario with reduction of the Pillar 1 payments by 50%, SUBshift60%: scenario with shifting of the Pillar 1 payments from Pillar 1 to Pillar 2 by 60%. b) TGM: total gross margin, c) UAA: utilized agricultural area.

3.2.4 Analysis of indicator values according to NUTS3 counties

This Subsection describes the development and the status of the economic, supply and environmental indicator values. The analysis is done at regional level for the NUTS3 counties where agricultural production is represented by 'regional farms'. The development of indicator values is related to the values of the baseline scenario CAP2003.

Development of economic indicator values

Subsidy volume and total gross margin

In the baseline scenario CAP2003 the subsidies increase in all counties between 12% and 99% compared to the situation in the reference year (REF) (cf. Subsection 3.1.3). In SUBred60% and in SUBshift70% the reduction of subsidies in all counties range between 40% and 90% compared to the baseline scenario.

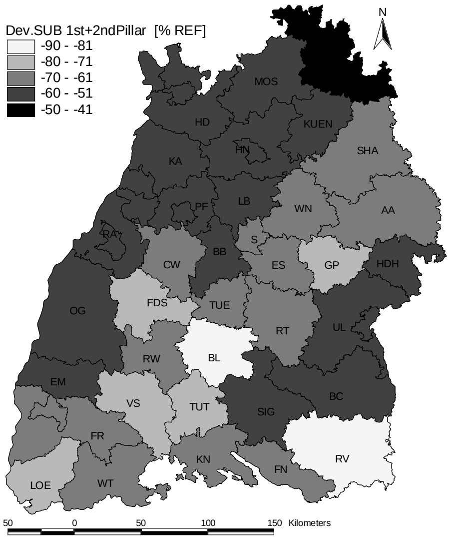
In the CAP2003 scenario the subsidy volume increased particularly significant in counties with high shares of grassland due to high increases of payments from Pillar 1 for grassland area. In SUBred60% and in SUBshift70% a reduction of payments from Pillar 1 affects the reduction of subsidy volume in both scenarios most extreme by 70pp to 90pp in the Southern part of the region, in Schwarzwald, in Schwäbische Alb, in Schwäbischer Wald and in Hohenlohe (Map 3.2-1 a to c). In counties with less grassland area the reduction of subsidy volume is smaller (less than 30pp to 40pp).

In SUBshift70% the reduction of payments from Pillar 1 is 10% higher than in SUBred60%, but the retained money is partially redistributed to Pillar 2 and therefore counties lose less subsidy volume in SUBshift70% than in SUBred60%.

The volume of payments from Pillar 2 in SUBshift70% increases in all counties due to the transfer from the retained money of Pillar 1. In SUBred60% the subsidy volume from Pillar 2 is reduced in some counties (e.g. TUE, FDS, BL) because some UAA is abandoned on which Pillar 2 payments had been paid before (cf. Map 3.2-1 e, f and Map 3.2-1 c).

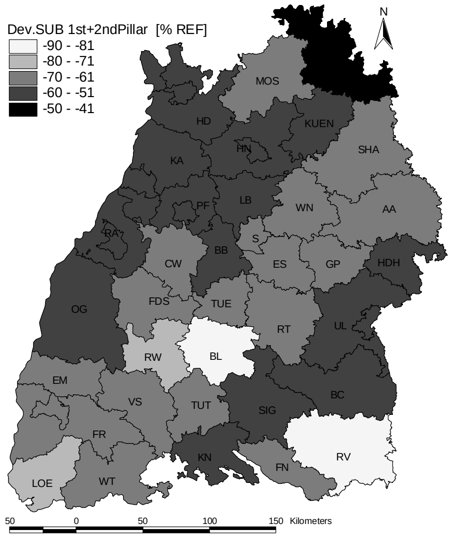
The development of the TGM excluding subsidies in the counties is similar in both scenarios (cf. Map 3.2-2 a, b). In counties with high cash crop production (e.g. TBB, MOS, HD) scenario SUBshift70% results in higher losses of TGM than in SUBred60% because in SUBshift70% arable land is set free from cash crop production by conversion into grassland or into abandoned UAA (cf. Map 3.2-4 d, f). Thus, here also the TGM excluding subsidies is reduced a bit more than in SUBred60% (cf. Map 3.2-2 a, b). In both scenarios most of the counties experience no or only small losses of TGM excluding subsidies compared to the baseline scenario CAP2003.

Map 3.2-1 a: Percentage change of subsidy volume in Pillar 1 and Pillar 2 in SUBred60%.



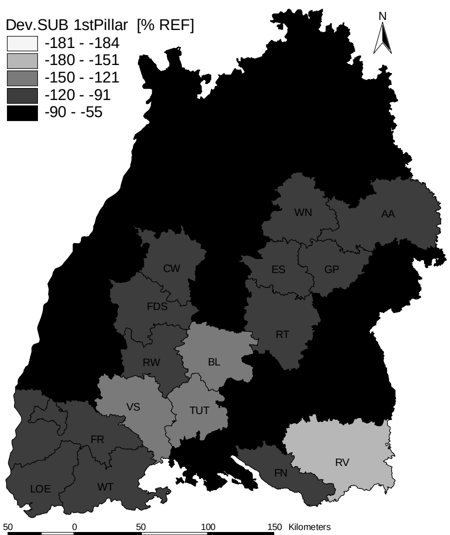
Notes: Unit: %, basis: REF.

Map 3.2-1 b: Percentage change of subsidy volume in Pillar 1 and Pillar 2 in SUBshift70%.



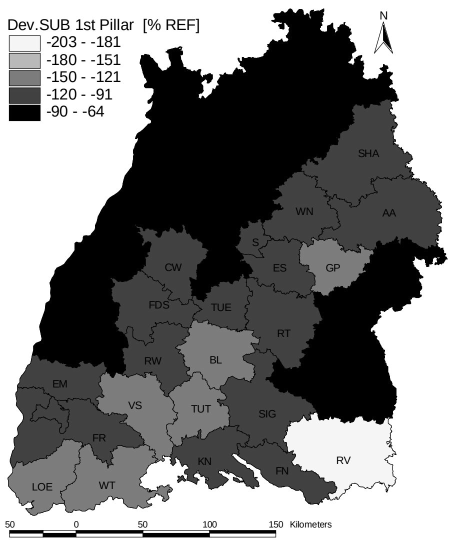
Notes: Unit: EUR ha^{-1}.

Map 3.2-1 c: Percentage change of subsidy volume in Pillar 1 compared to CAP2003.



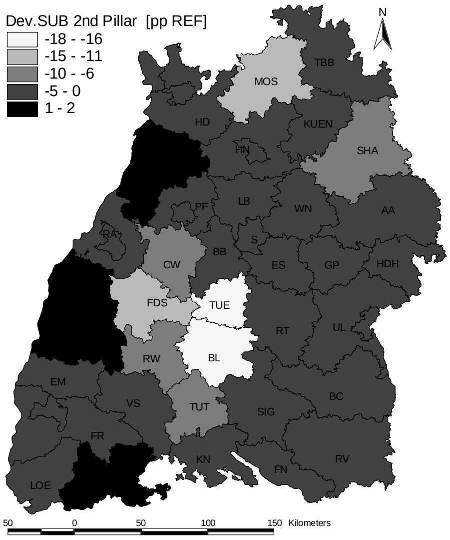
Notes: Unit: %, basis: REF.

Map 3.2-1 d: Percentage change of subsidy volume in Pillar 1 in SUBshift70% compared to CAP2003.



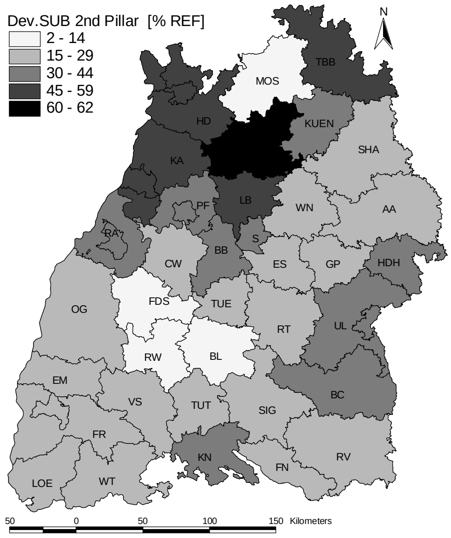
Notes: Unit: EUR ha^{-1}.

Map 3.2-1 e: Percentage change of subsidy volume in Pillar 2 in SUBred60% compared to CAP2003.



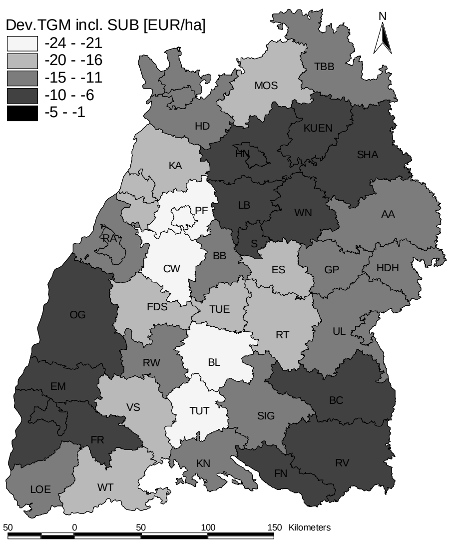
Notes: Unit: %, basis: REF.

Map 3.2-1 f: Percentage change of subsidy volume Pillar 2 in SUBshift70% compared to CAP2003.



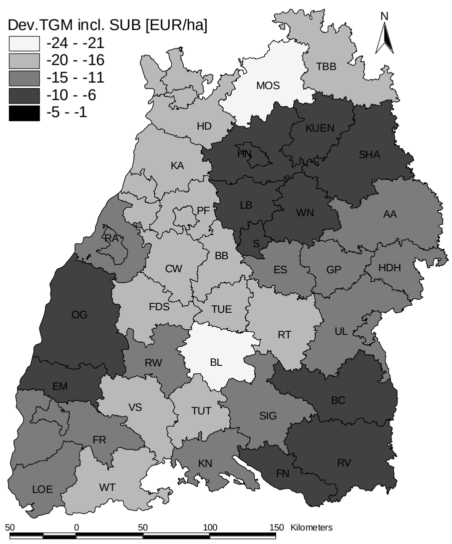
Notes: Unit: EUR ha-1.

Map 3.2-2 a: Percentage change of TGM incl. SUB in SUBred60% compared to CAP2003.



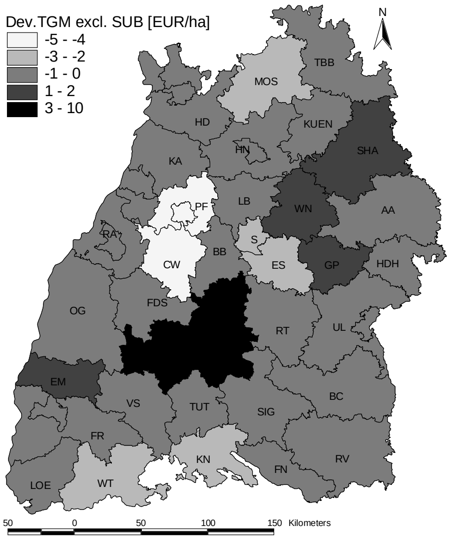
Notes: Unit: %, basis: REF.

Map 3.2-2 b: Percentage change of TGM incl. SUB in SUBshift70%.



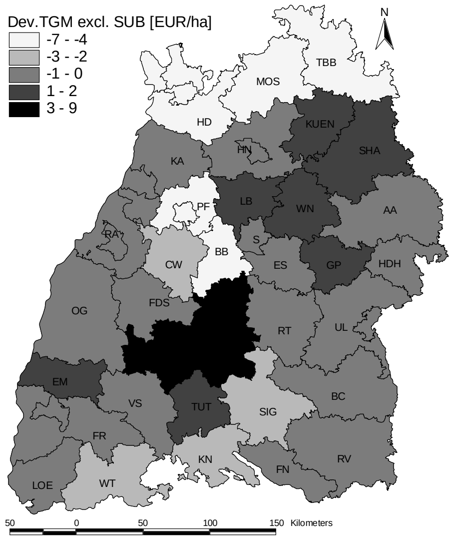
Notes: Unit: EUR ha-1.

Map 3.2-2 c: Percentage change of TGM excl. SUB in SUBred60% compared to CAP2003.



Notes: Unit: %, basis: REF.

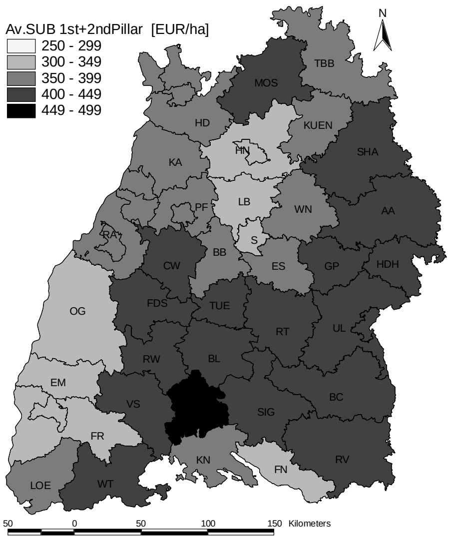
Map 3.2-2 d: Percentage change of TGM excl. SUB in SUBshift70% compared to CAP2003.



Notes: Unit: EUR ha^{-1}.

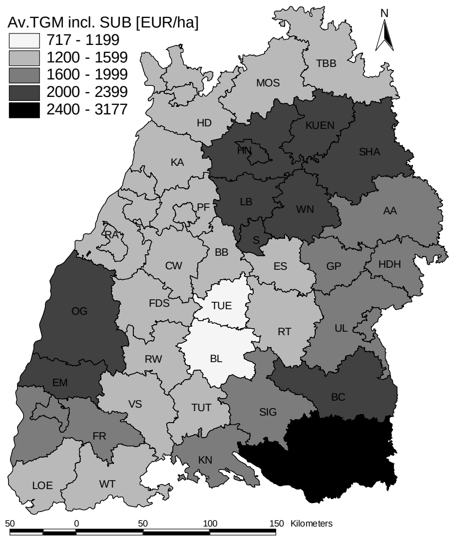
In the baseline scenario CAP2003 the distributions of average subsidy volume is quite heterogeneous (cf. Subsection 3.1.3, Maps 3.2-3 a, b). Counties with high shares of grassland received on average higher average subsidies than counties with higher shares of arable land with cereals production or special crops production. The income is also regionally heterogeneous in CAP2003 and favours the counties with high animal production and special crops. In the scenarios SUBred60% and SUBshift70% subsidy volume is reduced and also the heterogeneity of subsidy distribution is reduced. For most of the counties only two different levels of average subsidies are represented. Only the two extensive counties VS and TUT have higher average subsidies (e.g. VS, TUT; cf. Maps 3.2-3 c, d). The average TGM is similar distributed as in the baseline scenario, because the increase of TGM is strongly driven by increased market prices and yields (which are the same in CAP2003, SUBred60% and SUBshift70%) (cf. Maps 3.2-3 e, f).

Map 3.2-3 a: Average subsidy volume in Pillar 1 and Pillar 2 in CAP2003.



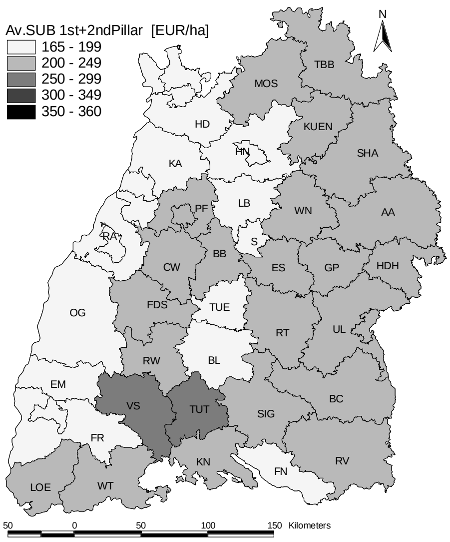
Notes: Unit: EUR ha^{-1}.

Map 3.2-3 b: Average TGM incl. SUB in CAP2003.



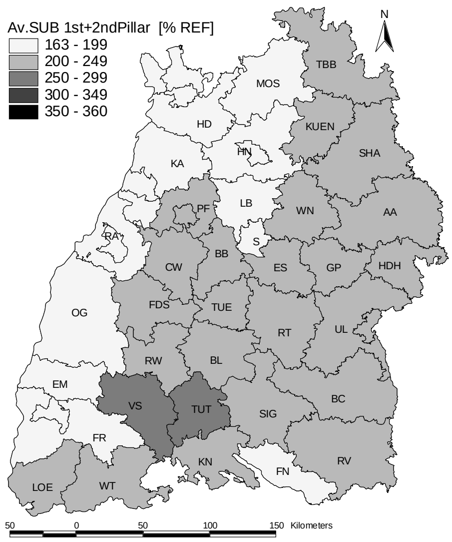
Notes: Unit: EUR ha^{-1}.

Map 3.2-3 c: Average subsidy volume from Pillar 1 and Pillar 2 in SUBred60%.



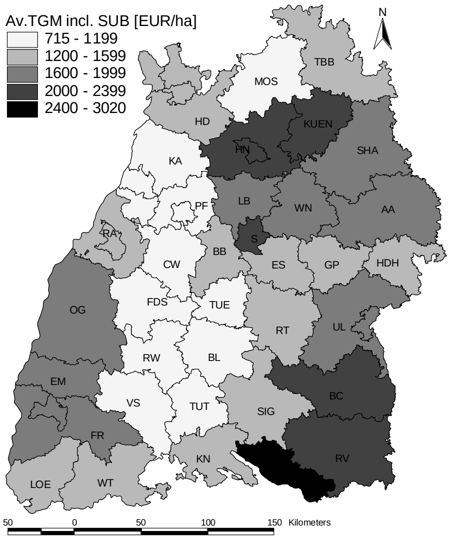
Notes: Unit: EUR ha^{-1}.

Map 3.2-3 d: Average TGM incl. SUB in SUBshift70%.



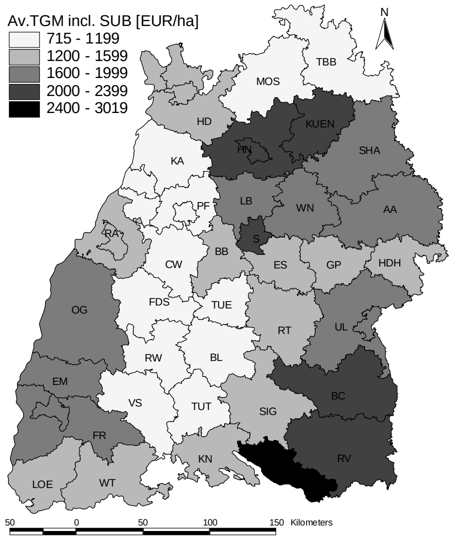
Notes: Unit: EUR ha^{-1}.

Map 3.2-3 e: Average SUBvol in SUBred60%.



Notes: Unit: EUR ha^{-1}.

Map 3.2-3 f: Average SUBvol in SUBshift70%.



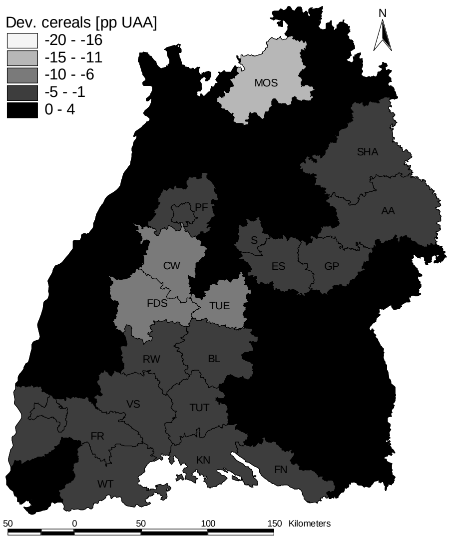
Notes: Unit: EUR ha^{-1}.

Development of supply indicator values

Crop production

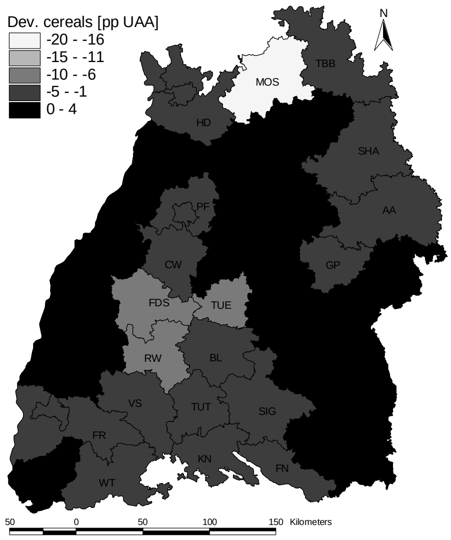
In both scenarios SUBred60% and SUBshift70% cereals production decreases in several counties. In the counties MOS, FDS and TUE the reduction of cereals area occurs to be extreme (cf. Maps 3.2-4 a, b) because here larger shares of UAA fall out of production (cf. Maps 3.2-4 g, h). The extensive counties in Schwarzwald and Schwäbische Alb let extensive grassland area fall abandoned (Maps 3.2-4 i, j) because the reduced subsidies decrease the profitability of grassland management.

Map 3.2-4 a: Change of cereals area in SUBred60% compared to CAP2003.



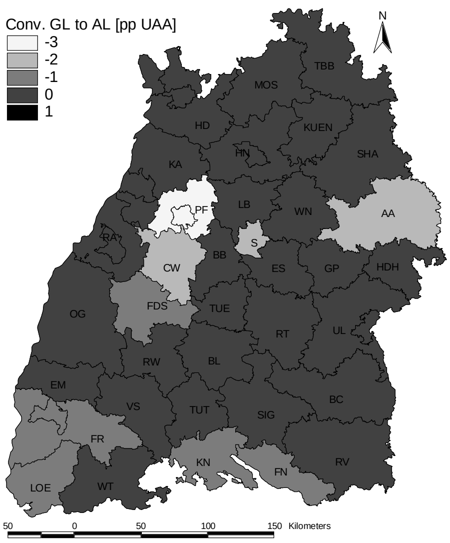
Notes: Unit: %, basis: REF.

Map 3.2-4 b: Change of maize area in SUBshift70% compared to CAP2003.



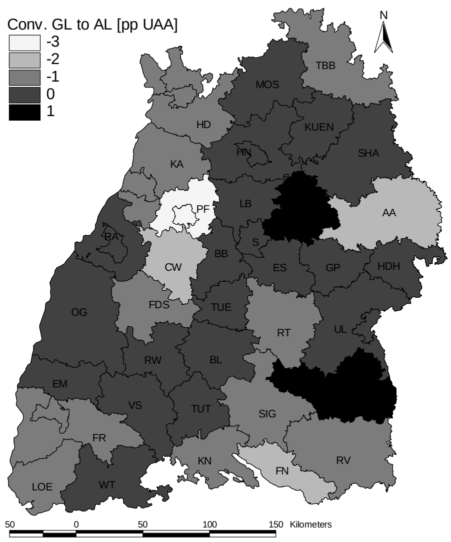
Notes: Unit: %, basis: REF.

Map 3.2-4 c: Conversion of arable land into grassland in SUBred60% compared to CAP2003.



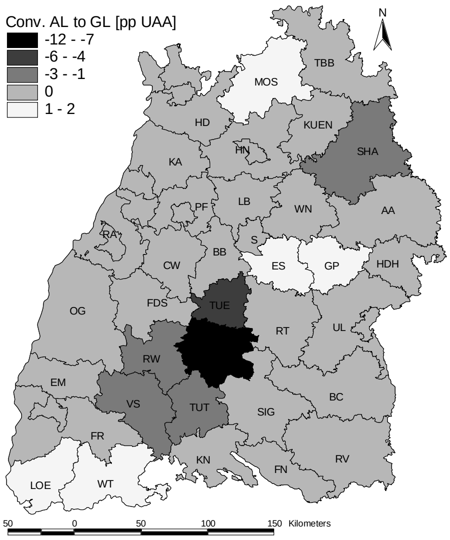
Notes: Unit: %, basis: REF.

Map 3.2-4 d: Conversion of grassland into arable land in SUBshift70% compared to CAP2003.



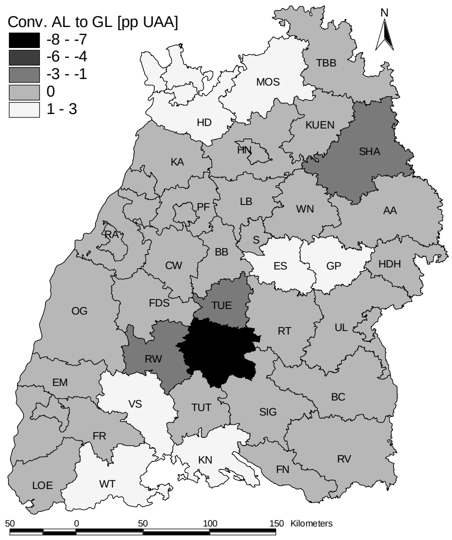
Notes: Unit: %, basis: REF.

Map 3.2-4 e: Conversion of grass land into arable in SUBred60% compared to CAP2003.



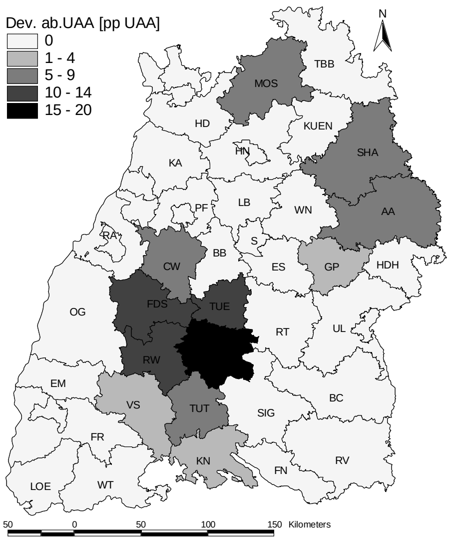
Notes: Unit: %, basis: REF.

Map 3.2-4 f: Conversion of grass land into arable in SUBshift70% compared to CAP2003.



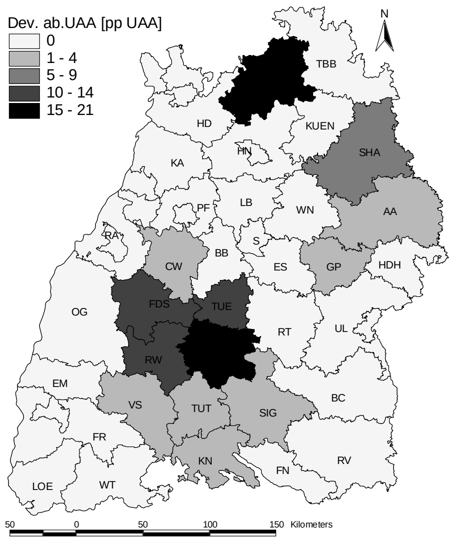
Notes: Unit: %, basis: REF.

Map 3.2-4 g: Change of abandoned UAA area in SUBred60% compared to CAP2003.



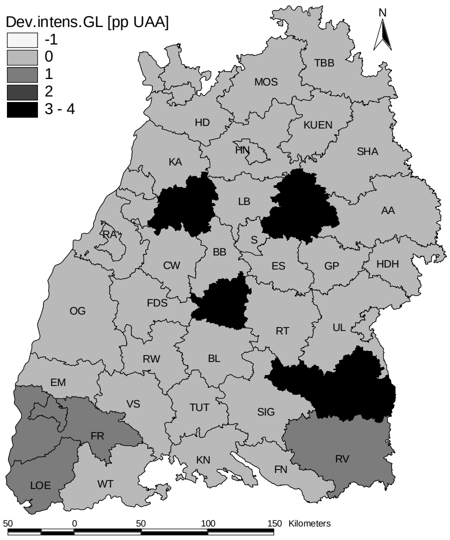
Notes: Unit: %, basis: REF.

Map 3.2-4 h: Change of abandoned UAA area in SUBshift70% compared to CAP2003.



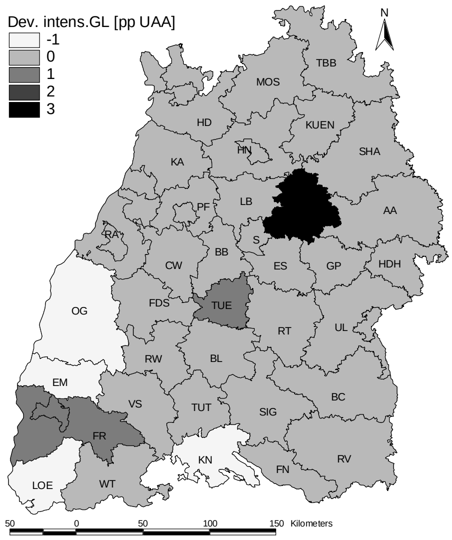
Notes: Unit: %, basis: REF.

Map 3.2-4 i: Change of intensive grassland area in SUBred60% compared to CAP2003.



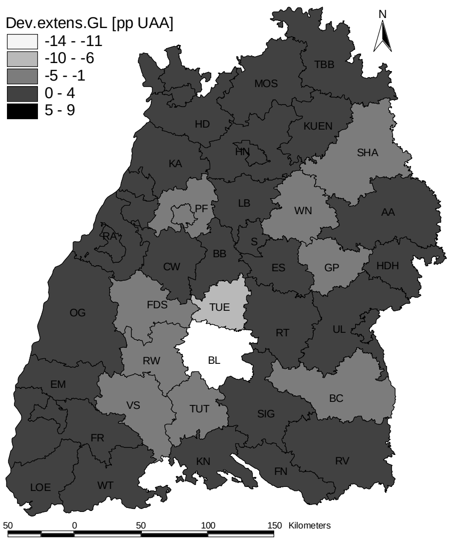
Notes: Unit: %, basis: REF.

Map 3.2-4 j: Change of intensive grassland area in SUBshift70% compared to CAP2003.



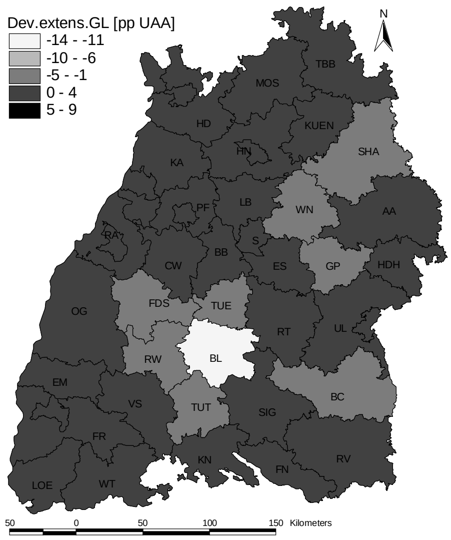
Notes: Unit: %, basis: REF.

Map 3.2-4 k: Change of extensive grassland area in SUBred60% compared to CAP2003.



Notes: Unit: %, basis: REF.

Map 3.2-4 l: Change of extensive grassland area in SUBshift70% compared to CAP2003.



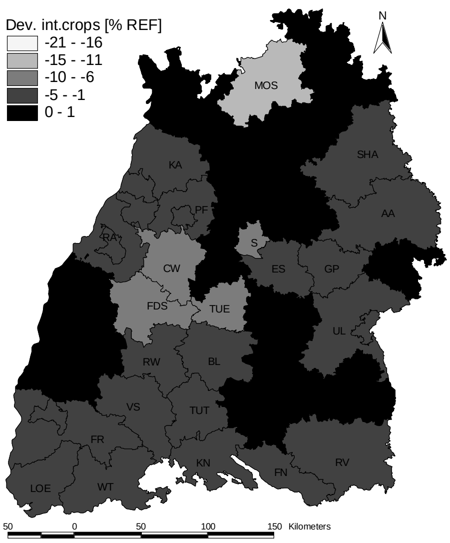
Notes: Unit: %, basis: REF.

Crop production intensity and animal production

Maps 3.2-5 a to d present the developments of intensive crops area and intensive variant area in the subsidy reduction scenarios SUBred60% and SUBshift70%. In both scenarios the reduction of intensive crops area is caused by the reduction of cereals area and thus the spatial distribution is similar to the reduction of cereals production. The single counties MOS and LB show higher increases in intensive crop variants area, which is caused by an increase in cereals production variants. Due to reduced subsidies UAA falls regionally out of production and some NUTS3 counties increase the production intensity on the remaining area for aiming at higher yields (e.g. in MOS and BB).

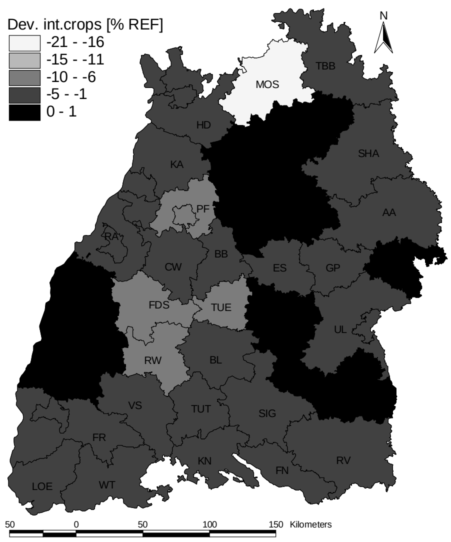
With regard to changes in bull stocks there are no big differences between the projected scenario results of SUBred60% and SUBshift70%. Bulls stock changes only slightly and only in some single counties (cf. Maps 3.2-5 e, f). The largest absolute changes are projected in the counties with a high bull density (i.e. VVS, HDH with bulls density of 10 to 14 heads per 100ha) (cf. Section 2.2, Map 2.3.5 b).

Map 3.2-5 a: Change of intensive crops area in SUBred60% compared to CAP2003.



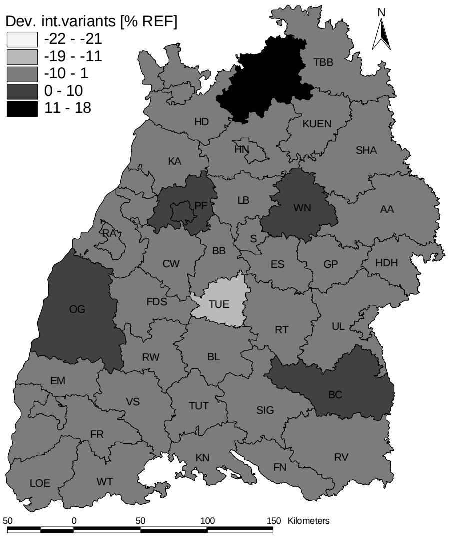
Notes: Unit: %, basis: REF.

Map 3.2-5 b: Change of intensive variants in SUBshift70% compared to CAP2003.



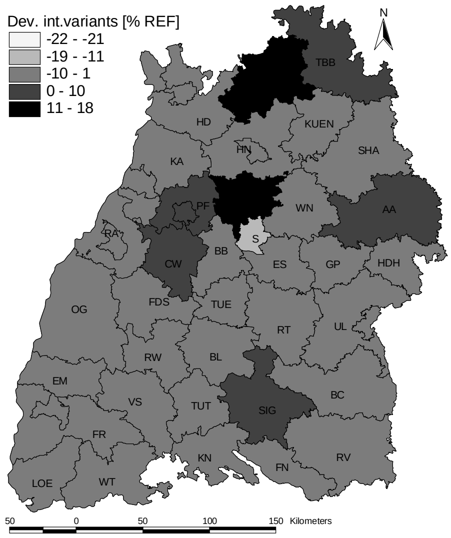
Notes: Unit: %, basis: REF.

Map 3.2-5 c: Change of intensive variant area in SUBred60% compared to CAP2003.



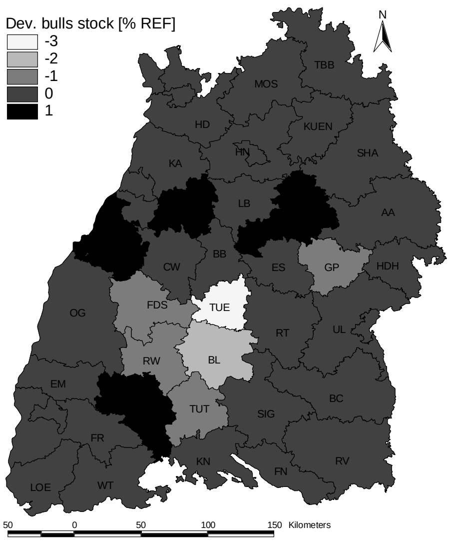
Notes: Unit: %, basis: REF.

Map 3.2-5 d: Change of intensive variant area in SUBshift70% compared to CAP2003.



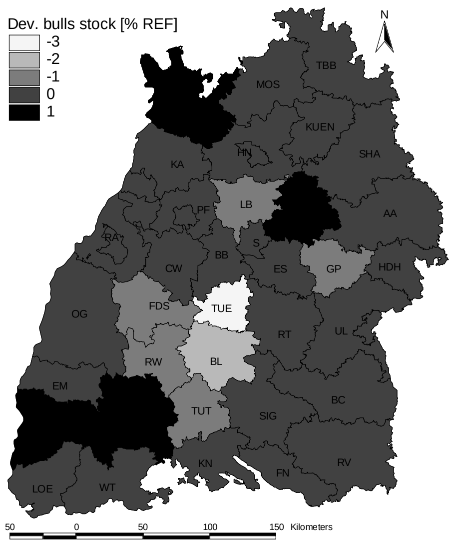
Notes: Unit: %, basis: REF.

Map 3.2-5 e: Percentage change of bull stock in SUBred60% compared to CAP2003.



Notes: Unit: %, basis: REF.

Map 3.2-5 f: Percentage change of bulls stock in SUBshift70% compared to CAP2003.



Notes: Unit: %, basis: REF.

Development of environmental indicator values

Maps 3.2-6 a to d present the development of nitrogen intensity and erosion potential projected for the scenarios SUBred60% and SUBshift70%. In both scenarios most of the NUTS3 counties tend to reduce the nitrogen input due to a reduced crop production intensity and decreased nitrogen demand. However, in some single counties an increase of nitrogen intensity is projected (e.g. in FDS, RW). This increase of nitrogen intensity is caused by abandoning of UAA, because the produced manure from livestock has to be deposed on less UAA, which increases the intensity of nitrogen fertilization. The increase of production of intensive crops and crop variants might be of relevance for increased nitrogen input only in a few counties (e.g. in MOS).

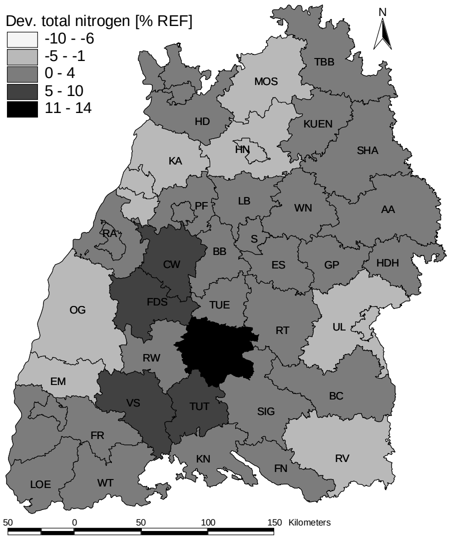
The values of the weighted nitrogen input which considers the impact of intercropping is unchanged or decreases in most of the counties (cf. Map 3.2-6 c, d). However, in the counties MOS and VVS even the weighted indicator value of nitrogen increases.

Erosion potential tends to increase slightly in arable counties in the South where the reduced total area of arable land results in a higher calculated erosion potential (the erosion potential is calculated in relation to the total arable area (cf. Section 2.1). Changes of GHG emission are small due to only marginal changes of livestock.

In SUBshift70% more counties show decreases of weighted nitrogen input and weighted erosion potential than in SUBred60%. This difference can be attributed to smaller decreases in intercrops area in SUBshift70% compared to SUBred60%.

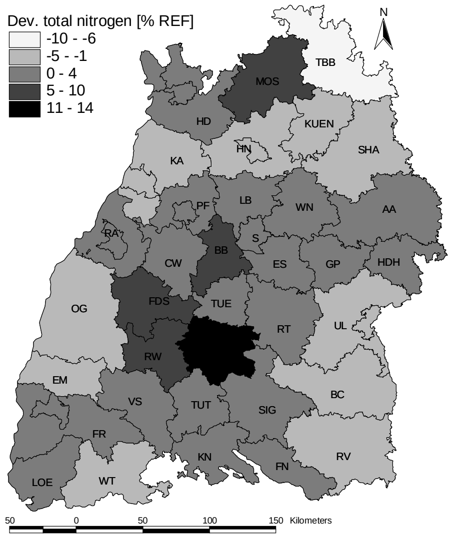
Maps 3.2-7 a to b present the development of potential AEM areas in SUBred60% and SUBshift70%. On average AEM area is reduced in both scenarios due to the abandoning of UAA. However, the reduction is less pronounced in SUBshift70%; where several counties show an increase of AEM area due to the activities which receive increased AEM payments from Pillar 2: extensive and intensive grassland (cf. Maps 3.2-4 i, j) and intercropping area (cf. Maps 3.2-7 i, j).

Map 3.2-6 a: Percentage change of total nitrogen input in SUBred60% compared to CAP2003.



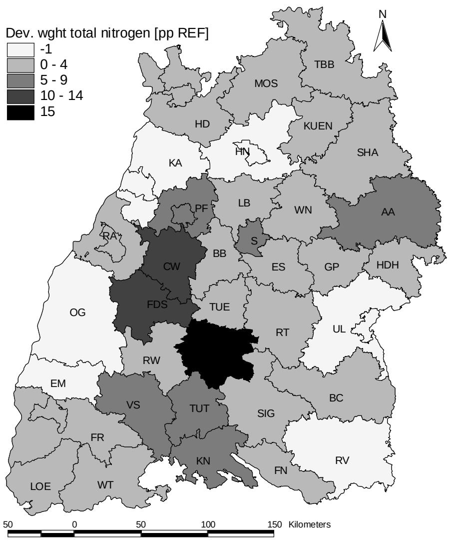
Notes: Unit: %, basis: REF.

Map 3.2-6 b: Percentage change of total nitrogen input in SUBshift70% compared to CAP2003.



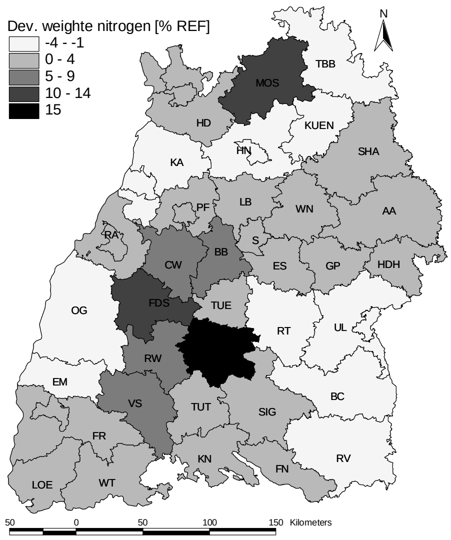
Notes: Unit: kg ha^{-1}.

Map 3.2-6 c: Percentage weighted total nitrogen input in SUBred60% compared to CAP2003.



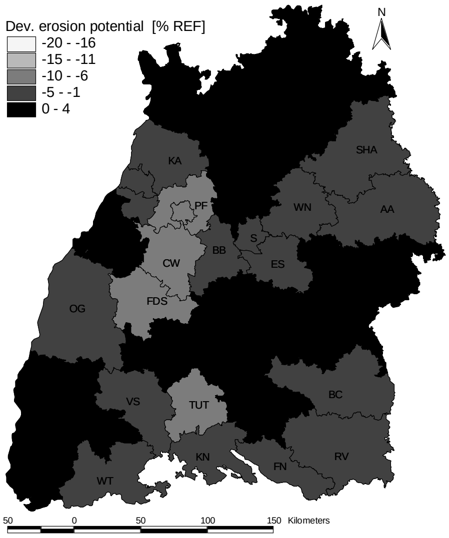
Notes: Unit: %, basis: REF.

Map 3.2-6 d: Percentage weighted total nitrogen input in SUBshift70% compared to CAP2003.



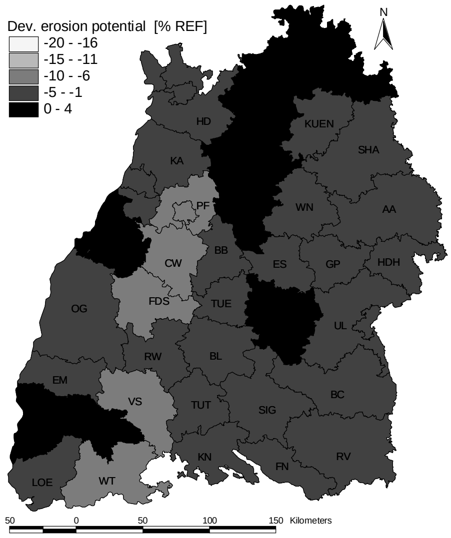
Notes: Unit: %, basis: REF.

Map 3.2-6 e: Percentage change of erosion potential in SUBred60% compared to CAP2003.



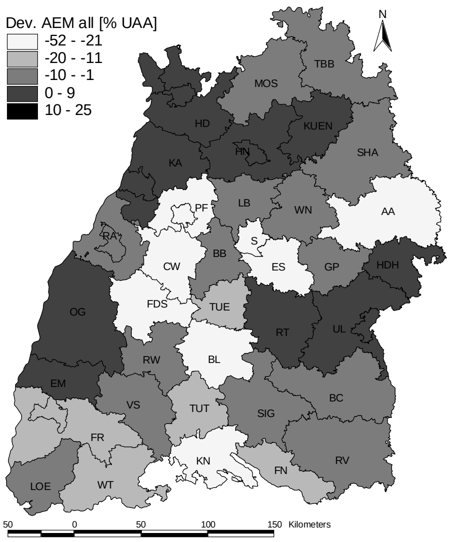
Notes: Unit: pp, basis: REF.

Map 3.2-6 f: Erosion potential in SUBshift70% compared to CAP2003.



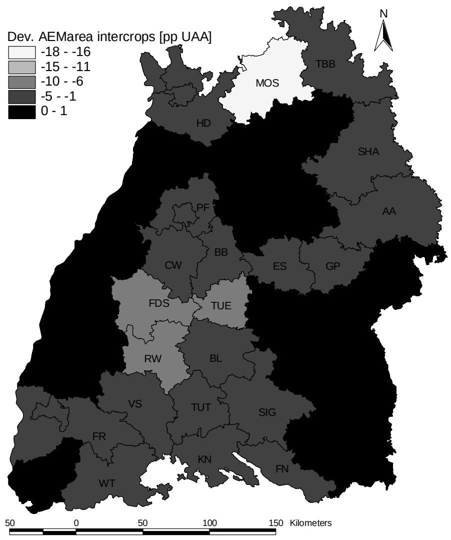
Notes: Unit: % of uncovered fallow.

Map 3.2-7 a: Change of total potential AEM area in SUBred60% compared to CAP2003.



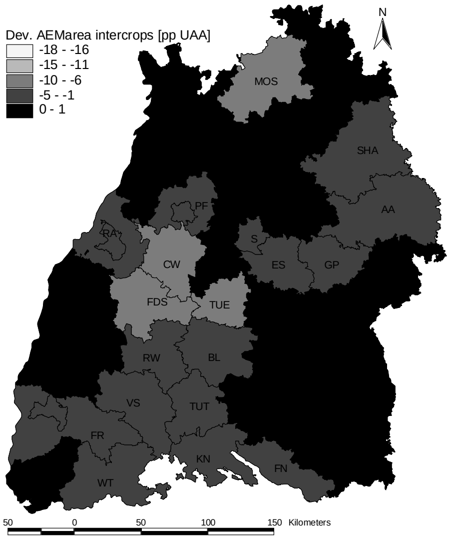
Notes: Unit: %, basis: REF.

Map 3.2-7 b: Potential total potential AEM area in SUBshift70%.



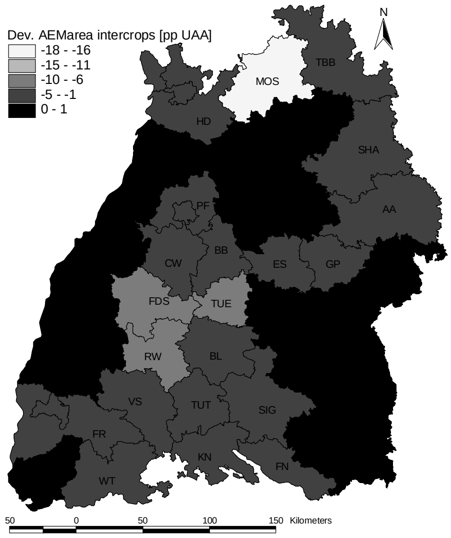
Notes: Unit: % UAA.

Map 3.2-7 c: Change of intercrops area in SUBred60% compared to CAP2003.



Notes: Unit: %, basis: REF.

Map 3.2-7 d: Intercrops area in SUBshift70%.



Notes: Unit: % UAA.

3.2.5 Analysis of indicator value development according to farm types

Development of economic indicator values

The economic indicators are significantly impacted by the modified direct payments. Table 3.2-5 presents the results of the subsidy reduction scenarios SUBred60% and SUBshift70% for the farm types in comparison to the baseline scenario CAP2003. The scenarios SUBred60% and SUBshift70% result in a subsidy volume which is for the complete study region by 63% and 62% smaller than in the baseline scenario CAP2003. This reflects a positive effect for the objective to reduce public expenditures. Grassland farm types (GL-IG and GL-EG) are affected most, with reductions of subsidies of more than 60% to 70% in comparison to the CAP2003 scenario. Due to the scenario assumptions, the reduction of the payments from Pillar 1 is in the SUBshift70% scenario at least 10pp larger than in the SUBred60% scenario. The SUBred60% scenario results also show slight reduction of payments from Pillar 2; this is attributable to abandoning of UAA. In SUBshift70% payments from Pillar 2 are increased by the money deducted from Pillar 1 and shifted to Pillar 2. From this shift of payments in SUBshift70% arable farm types show higher benefits than grassland counties, with relative increases of payments from Pillar 2 being between 30% and 40% higher in arable counties than in grassland counties.

Both subsidy reduction scenarios result in an average decrease in total gross margin of -11pp in the complete study region in comparison to the CAP2003 scenario. The losses in TGM are with 20pp higher in GL-EG than in the other farm types with 12pp and 13pp. TGM excluding subsidies is not significantly changed, i.e. it is almost equal to the one in the CAP2003 baseline scenario (cf. Subsection 3.3.3).

The modified direct payments result also in a change of distribution of subsidies and income. Table 3.2-4 presents the average values of subsidies and income as well as the relative and absolute deviation from the value of the complete region. The ranges of absolute deviations are smaller in both subsidy reduction scenarios (e.g. -29 EUR ha^{-1} to +21 EUR ha^{-1} in SUBshift70%) than in the CAP2003 scenario (e.g. -40 EUR ha^{-1} to +35 EUR ha^{-1}). However, the ranges of total gross margin deviations are larger in the subsidy reduction scenarios (e.g. -527 EUR ha^{-1} to +43 EUR ha^{-1} in SUBred60%) than in the CAP2003 scenario, whereas the relative deviations are similar in both subsidy reduction scenarios to the deviations in CAP2003.

Table 3.2-4: Average subsidy volume and total gross margin in CAP2003, SUBred60% and SUBshift70% scenarios and deviations of farm types from the average value.

	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]
	Baseline scenario (CAP203)																	
	EUR ha^{-1}						%						absolute differences from BW [EUR ha^{-1}]					
SUBvol[m]	364	407	351	405	426	391	93	104	90	103	109	100	-27	16	-40	14	35	0
SUBvol[m] Pillar 1	275	300	273	297	302	289	95	104	94	103	104	100	-14	11	-16	8	13	0
SUBvol[m] Pillar 2	90	106	78	108	124	102	88	104	76	105	122	100	-12	4	-24	6	22	0
TGMvol[n] incl. SUB	1832	1748	1864	1936	1283	1796	102	97	104	108	71	100	36	-48	68	140	-513	0
TGMvol[n] excl. SUB	1468	1341	1513	1531	858	1404	105	96	108	109	61	100	64	-63	109	127	-546	0
	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]
	SBUred60%																	
	EUR ha^{-1}						%						absolute differences from BW					
SUBvol[m]	196	221	187	222	226	212	92	104	88	105	106	100	-16	9	-25	10	14	0
SUBvol[m] Pillar 1	108	117	109	116	111	112	96	105	97	104	99	100	-4	5	-3	4	-1	0
SUBvol[m] Pillar 2	88	104	78	106	115	99	89	105	79	107	116	100	-11	5	-21	7	16	0
TGMvol[n] incl. SUB	1662	1553	1695	1749	1089	1616	103	96	105	108	67	100	46	-63	79	133	-527	0
TGMvol[n] excl. SUB	1466	1332	1508	1527	863	1404	104	95	107	109	61	100	62	-72	104	123	-541	0
	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]
	SUBshift70%																	
	EUR ha^{-1}						%						absolute differences from BW					
SUBvol[m]	195	220	184	226	234	213	92	103	86	106	110	100	-18	7	-29	13	21	0
SUBvol[m] Pillar 1	81	87	81	87	84	84	96	103	97	104	100	100	-3	3	-3	3	0	0
SUBvol[m] Pillar 2	114	133	102	138	149	129	89	103	79	107	116	100	-15	4	-27	9	20	0
TGMvol[n] incl. SUB	1655	1544	1693	1753	1098	1611	103	96	105	109	68	100	44	-67	82	142	-513	0
TGMvol[n] excl. SUB	1460	1324	1509	1527	865	1398	104	95	108	109	62	100	62	-74	111	129	-533	0

a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated.

Development of supply and environmental indicator values

In both subsidy reduction scenarios UAA fall abandoned in almost all counties. However, the redistributed payments from Pillar 1 to Pillar 2 allow in SUBshift70% a slightly lower share of abandoned UAA in the farm types GL-FC and GL-EG. On the other hand, more UAA falls abandoned in AL-FC in SUBshift70% because the increased payments for AEM have only a small impact here. Most of the payments in AL-FC are payments for intercropping on arable land. Payments for AEM on grassland are higher, but due to small shares of arable land the payments for AEM in AL-FC are in total small. In both scenarios land abandoning appears most pronounced in GL-EG, which are the problematic farm types for supply objectives due to high extensification of agricultural production. In GL-EG agricultural productivity is that small, that high reductions of subsidies result in the abandoning of marginal arable land. Thus, it seems as if specific policy measures would need to be applied to avoid such an abandoning of UAA.

In both subsidy reduction scenarios intensive crop area tends to decrease due to reduction of cash crop area. Animal production does not change, because it is not affected by the modelled changes of subsidies. Environmental indicator values and potential AEM area change slightly due to the abandoned UAA, which reduces the potential AEM and the related area for the average nitrogen input.

Table 3.2-5: Development of indicators values in SUBred60% and SUBshift70%.

		SUBred60%						SUBshift70%					
		AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	All[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	All[g]
SUB[m] volume	[%]	-58	-59	-66	-71	-73	-63	-58	-59	-67	-69	-70	-62
SUB volume Pillar 1	[%]	-69	-74	-100	-119	-109	-82	-81	-86	-117	-138	-125	-95
SUB volume Pillar 2	[%]	-2	-3	0	-2	-7	-3	39	29	21	22	19	27
TGM[n] volume incl. SUB	[%]	-12	-13	-11	-12	-19	-11	-13	-14	-11	-12	-18	-11
TGM volume excl. SUB	[%]	0	-1	0	0	1	0	-1	-2	0	0	2	0
Cereals	[pp][o]	-1	-2	-1	-2	-4	-1	-1	-4	0	-1	-4	-2
Maize	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Fodder crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Others[p]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Root crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Oil seeds and legumes	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Set-aside area	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Conv. of grassland[q]	[pp][o]	0	0	0	-1	0	0	-1	0	-1	-1	0	0
Conv. of arable land[r]	[pp][o]	0	0	0	1	-2	0	0	0	0	1	-1	0
Intensive grassland	[pp][o]	0	1	1	1	0	0	0	0	0	1	0	0
Extensive grassland	[pp][o]	-1	0	0	-1	-3	-1	0	1	1	0	-2	0
Abandoned UAA[s]	[pp][o]	1	2	0	2	8	2	1	4	0	1	7	3
Dairy cows	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Bulls	[%]	0	0	0	0	-1	0	0	0	0	0	-1	-1
Fattening pigs	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Intensive crop area	[pp][o]	-2	-3	-1	-2	-5	-2	-2	-5	-1	-2	-4	-2
Intensive variant area	[pp][o]	-1	2	1	1	0	1	-2	2	0	0	0	1
Nitrogen total	[%]	1	1	0	2	5	1	0	1	0	1	4	1
Nitrogen total (weight.)[t]	[%]	1	1	0	2	7	2	1	3	0	1	5	2
Nitrogen organic	[%]	0	0	0	0	-1	0	0	0	0	0	-1	0
Nitrogen demand	[%]	0	-1	0	1	3	1	-1	-1	0	0	2	-1
Erosion potential	[pp][u]	-1	0	0	-2	-3	0	-1	-1	-1	-2	-4	0
Erosion pot.(weight.)[t]	[pp][u]	0	1	0	0	-2	1	-1	1	-1	-2	-2	1
GHG[v] emissions	[%]	0	-1	0	0	-2	-1	-1	-1	0	0	-2	-1
Potential AEM area[w]	[pp][o]	-10	-6	-5	-10	-18	-8	-9	-13	-3	-6	-13	-8

Notes: a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percent share of UAA/percentage points of UAA compared to the share in reference situation. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare/difference in percent. u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. v: Potential in percent of uncovered arable land/difference in percent. w: Green house gas. x: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity.

3.2.6 Analysis of results according to achievement of policy objectives

Due to their specific agricultural structure single counties and the farm types are affected differently by the modified subsidies with respect to the developments in economic, production and environmental indicator values.

The simulated policy affects the farm types mostly with respect to changes in the values of the economic indicators subsidies and total gross margin. Agricultural production is less affected by the scenarios and the environmental indicators are only partially affected. Table 3.2-6 summarizes the observed development of the indicator values and the impact on the policy objectives in comparison to the CAP2003 situation

The decreased subsidy volume indicates a positive development with respect to the objective of subsidy reduction for all farm types in both scenarios. In SUBshift70% the payments from Pillar 2 are increased due to shifting the money from Pillar 1 to Pillar 2. However, the total subsidy volume still shows a decrease. In SUBred60% subsidy payments from Pillar 2 are decreased in the farm type GL-EG.

Both scenarios result in a decrease of the TGM. In comparison to the CAP2003 scenario the negative distributional effect is less for subsidies but it is similar or even more negative for the distribution of the income.

The supply objective is not significantly influenced with respect to production. Changes in productions are small, however all farm types show a negative development of retaining UAA and the potential AEM area also decreases, i.e. shows a negative development.

Table 3.2-6: Impact on policy objectives in SUBred60% and SUBshift70%.

		SUBred60%						SUBshift70%					
		AL-CC[a]	**AL-FC[b]**	**GL-IG[c]**	**GL-FC[d]**	**GL-EG[e]**	**All[g]**	**AL-CC[a]**	**AL-FC[b]**	**GL-IG[c]**	**GL-FC[d]**	**GL-EG[e]**	**All[g]**
SUB[m] volume	[%]	++	++	++	++	++	++	++	++	++	++	++	++
SUB volume Pillar 1	[%]	++	++	++	++	++	++	++	++	++	++	++	++
SUB volume Pillar 2	[%]	0	0	0	0	+	0	- -	- -	- -	- -	- -	- -
TGM[n] volume incl. SUB	[%]	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
TGM volume excl. SUB	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Cereals	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Maize	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Fodder crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Others[p]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Root crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Oil seeds and legumes	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Set-aside area	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Conv. of grassland[q]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Conv. of arable land[r]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Intensive grassland	[pp][o]	0	0	0	0	0	0	0	0	0	1	0	0
Extensive grassland	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Abandoned UAA[s]	[pp][o]	0	0	0	0	-	0	0	0	0	0	-	0
Dairy cows	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Bulls	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Fattening pigs	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Intensive crop area	[pp][o]	0	0	0	0	+	0	0	+	0	0	0	0
Intensive variant area	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen total	[%]	0	0	0	0	-	0	0	0	0	0	0	0
Nitrogen total (weight.)[t]	[%]	0	0	0	0	-	0	0	0	0	0	-	0
Nitrogen organic	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen demand	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Erosion potential	[pp][u]	0	0	0	0	0	0	0	0	0	0	0	0
Erosion pot.(weight.)[t]	[pp][u]	0	0	0	0	0	0	0	0	0	0	0	0
GHG[v] emissions	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Potential AEM area[w]	[pp][o]	- -	+	0	- -	- -	0	- -	0	0	0	- -	-

Notes: a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percentage points of utilized agricultural area compared to the share in reference situation. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. u: Percentage points difference from reference situation. v: Green house gas. w: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity.
+ small positive impact on objective, ++ medium positive impact on objective, +++ highest positive impact on objective
- small negative impact on objective, - - medium positive impact on objective, - - - highest positive impact on objective, 0: no impact on objective

With respect to the single policy objectives the analysis of results allow the following conclusions.

Economic objectives

Reduction of subsidies due to high budgetary costs and the impact of reduced direct payments on income stabilisation

The policy objective of subsidy reduction is achieved as expected. Due to scenario definition the complete study region retains the same income as in the reference year. However, income compensating effects result from the assumptions of increasing yields and agricultural prices.

Adaption of direct payments due to negative distributional effects

As can be seen in the distribution of income and subsidies (cf. Subsection 3.2.4 and 3.2.5) the negative distributional effect remains in both subsidy reduction scenarios. While the negative distributional effect is reduced for subsidies, it still appears for the income. The modified direct payments are simulated in a relatively simple way, which does not fully address the objective of reducing the negative distributional effects. Thus, the simple reduction or the shifting of payments from Pillar 1 to Pillar 2 might not be appropriate to aim at the objective of reducing the negative distributional effects of subsidies and income which appears between intensive farming and extensive farming counties.

Limitations in modelling are given for the number of AEM, which could be simulated as regional activity at regional level. The few modelled AEM for arable land and grassland might not be sufficient to represent the entire mix of policy measures of Pillar 2, and modelling more measures of Pillar 2 might reflect the requirements of counties more adequately.

Supply objective: adaption of direct payments to retain UAA

The reduction of subsidy volume is reached under keeping most of the UAA in production, indicating that the simulated modified direct payments might be justified with regard to the objective of retaining UAA under production. However, it is projected that in some regions UAA is abandoned when direct payments are reduced and this can also not be avoided in the SUBshift70% scenario, where some payments are shifted from Pillar 1 to Pillar 2. Therefore a justification for direct payments in order to keep agricultural land is not fully given within these simulated policy scenarios. As for the negative distributional effects, the problem of land abandoning requires a better adapted and targeted policy measure in Pillar 2 than modelled here.

Environmental objective: Reduction of production intensity and environmental pressure

Compared to the CAP2003 scenario agricultural production does not change significantly in the scenarios assuming modified direct payments. However, the trend that reduced subsidies might result in regional extensification and regionally focused intensification of agricultural production can be observed for extensive NUTS3 counties and farm types. Environmental pressure shows slightly increasing tendency and is not repressed by the policy instruments.

3.2.7 Scenario discussion

In this Subsection two modelling assumptions are discussed: the assumptions of high price increases and the effect of abandoning of UAA under the limitation that a land market is not considered in the modelling approach. In addition, some policy recommendations are given based on the scenario results.

Public expenditures and agricultural income

The decrease of subsidy volume is simulated by the modification of the parameter direct payments from Pillar 1 and Pillar 2 in the scenarios SUBred60% and SUBshift70%. These parameter modifications are modelled in a simplified way and might not reflect the complexity needed, especially with regard to modifications of Pillar 2 payments.

With the regional production model used in this study payments from Pillar 2 can be only attributed to AEM which are modelled as production activities. AEM activities are defined only for intensive and extensive grassland farming as well as for intercropping[41]. Thus, Pillar 2 payments are attributed only to three AEM. Consequently, an extension of the number of AEM activities in the model and the attribution of Pillar 2 to more than three AEM activities could provoke different results for the scenario SUBshift70%.

The results of the scenarios SUBred60% and SUBshift70% are compared with the baseline scenario CAP2003, in order to describe the impact of the modified payments. In comparison to the baseline scenario CAP2003 the scenarios SUBred60% and SUBshift70% result in a decrease of subsidies by 63% and 62% and income decreased by 11%. However, in comparison to the reference year REF, in the scenarios SUBred60% and SUBshift70% the

[41] For more details on the modelling of AEM activities see Section 3.5.

subsidy volume is decreased by 11% and 12% while agricultural income is kept stable on average of the study region (cf. Subsection 3.2.3). This maintenance of the agricultural income level can be attributed to the scenario assumption of an increase in prices and yields, as this increase compensates for the monetary losses due to reduced subsidies. As mentioned in Section 3.1 the price assumptions from the year 2007 reflect extremely high prices and the scenario results would be different under assumption of smaller price increases. However, it has also to be kept in mind that due to increasing competition between food and energy production on agricultural area as well as due to increased demand for agricultural products, agricultural prices are generally expected to increase in the future.[42]

The effect of abandoning UAA

Both subsidy reduction scenarios result in shares of abandoned UAA which's extent for the total study region is assumed to be in an acceptable range. However, the UAA falling abandoned is projected to be regionally quite large, for example in fodder crop counties (e.g. SH, AA) and extensive grassland counties (e.g. FDS, BL).

In counties with abandoning of UAA it can be observed that small crop yields and reduced payments result even under assumptions of high prices in a small gross margin, so that it is not profitable for farmers to keep arable land in production. However, it is questionable if the model approach used in this study and the scenario assumptions are really suitable for a realistic simulation of abandoning of UAA. Thus, the following three aspects should be considered when comparing the model results with results expected in reality: (1) the optimization approach, (2) the assumptions of the 'regional farm approach' and (3) the fact that the alternative activity of energy crop production is not simulated.

Optimization approach

The model ACRE used in this study is an optimization model based on PMP, which optimises all agricultural activities by maximizing the total gross margin. The production activities are calibrated first to the reference situation (REF) and in the scenarios SUBred60% and SUBshift70% the extensions of the agricultural activities are changed in order to reach a new adapted maximum of TGM. To maximise TGM over all activities ACRE optimizes the extension of activities by extending those activities with high gross margin and reducing activities with small (or negative) gross margin. The scarce production factor of UAA is

[42] For a comparison with the prices used in this study and other baseline projections see Subsection 3.1.2.

allocated to the activities included in the solution. However, the flexibility in changing the extensions of production activities is restricted.

The subsidy reduction in both subsidy reduction scenarios results in an extreme decrease of the gross margins of crop activities and in some counties (e.g. in extensive counties) gross margins become negative due to relatively small yields. ACRE is not able to fill the UAA set free by increasing the extension of profitable activities. This does not seem to be an economic plausible reaction, since the scarce production factor UAA could be used in a profitable production to maximize the total gross margin.

PMP models find their optimum in the extension of activities where the marginal gross margins of the non-linear gross margin functions are equal for all activities (see Howitt 1995). The behaviour of a PMP model when modelling an extreme decrease in subsidies can be illustrated with an example. The following equations are derived from Umstaetter (1999) and describe the model constructed as a cost sided calibrated PMP model according to Howitt (1995). The corresponding parameters and values are presented in Table 3.2-7.

Linear programming model

Objective function LP model: $TGMlp = \sum_i (p_i * y_i + SUB_i - c_i) * X_i$

Resource constraint for land: $\sum_i X_i \le \sum_i \hat{X}_i$

Activity constraint for land: $X_i \le \hat{X}_i * 1.0001$

Non negativity condition for activity: $X_i \ge 0$

with

Calibration parameters for marginal crop (here oat)

Supply elasticity for marginal crop: $\varepsilon \ge 3.5$

Slope coefficient: $\gamma_i = \frac{c_i}{(\varepsilon * X_i)}$

Interception coefficient: $\alpha_i = c_i - 0.5 * \gamma_i * X_i$

Calibration parameter for the non marginal crop (wheat)

Adjustment term: $adj = \sum_i 0.5 * \gamma_i * X_i$

Slope coefficient: $\gamma_i = 2 * \frac{\lambda_i + adj_i}{X_i}$

Interception coefficient: $\alpha_i = c_i - \lambda_i + adj_i$

Objective function and restrictions for PMP model

Objective function PMP model:

$$TGMpmp = \sum_i (p_i * y_i + SUB_i - \alpha_i - 0.5 * \gamma_i * NX_i) * NX_i$$

Resource constraint for land:

$$\sum_i NX_i \le \sum_i X_i$$

Non negativity condition for activity:

$$NX_i \ge 0$$

Interception with Y-axix:

$$intercept_i = p_i * y_i + SUB_i - \alpha_i - 2*0.5*\gamma_i * NXzero_i$$

$$with \quad NXzero_i = 0$$

Marginal gross margin in PMP model:

$$MGMpmp_i = p_i * y_i + SUB_i - \alpha_i - 2*0.5*\gamma_i * NXopt_i$$

$$with \quad NXopt_{wheat} = 700; NXopt_{oat} = 300$$

Slope for marginal gross margin functions in PMP model:

$$slope_i = -(2*0.5*\gamma_i)$$

Table 3.2-7: Parameter symbols, production data and model results of the scenario calculations with the example model.

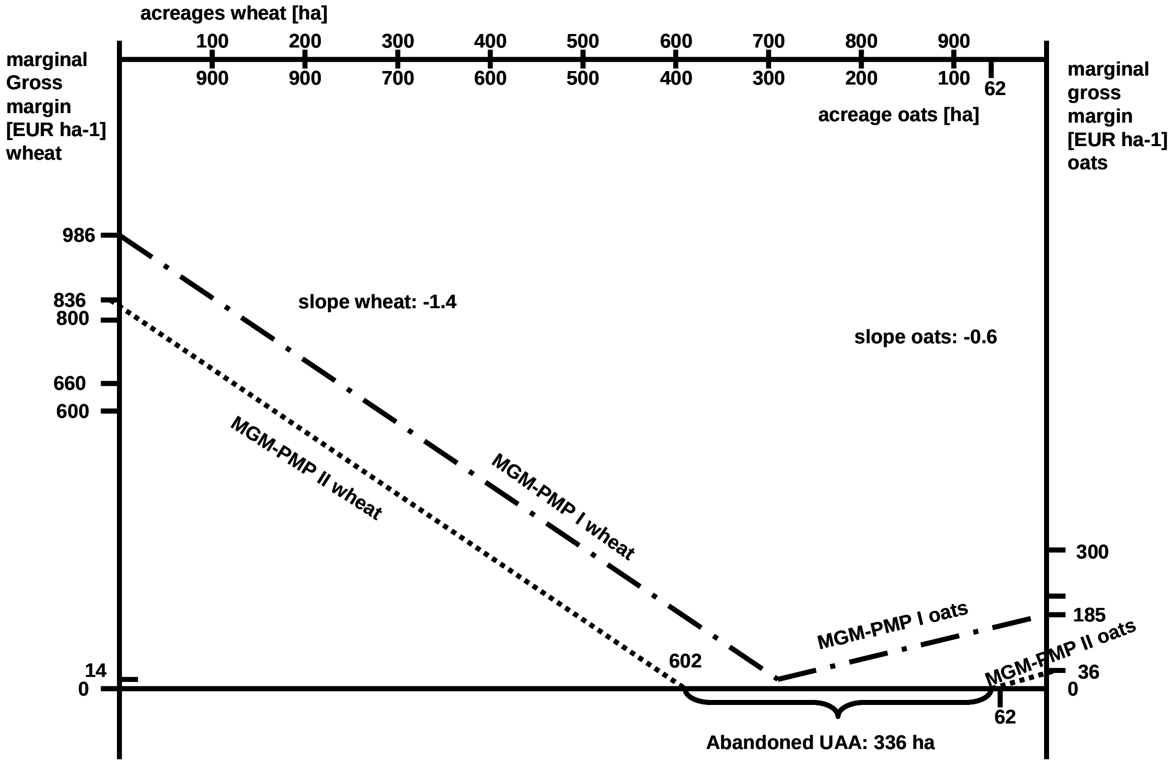
	Symbol	Unit	SCENARIO I		SCENARIO II	
			wheat	oats	wheat	oats
Production data						
Reference acreage	$\hat{X}_i$	[ha]	700	300	700	300
Crop yield	y_i	[dt ha^{-1}]	60	40	60	40
Price	p_i	[EUR dt^{-1}]	10	10	10	10
Variable costs	c_i	[EUR ha^{-1}]	400	600	400	600
Subsidies	SUB_i	[EUR ha^{-1}]	300	300	150	150
Model results and parameters						
Shadow prices	$\alpha_i = c_i - \lambda_i +$	[EUR ha$^{-1]}$	400	0	400	0
Acreage	$X_i; NX_i$	[ha]	700	300	602	62
Abandoned UAA	--	[ha]	0		336	
Total gross margin	$TGMpmp_i$	[EUR]	380000		252750	
Average gross margin	--	[EUR ha^{-1}]	500	100	350	-50
Marginal gross margin	MGM_i	[EUR ha$^{-1]}$	14.286	14.286	1.4 E-10	8.6E-11
Intercept	$intercept_i$	[EUR ha^{-1}]	986	186	836	36
Slope	$slope_i$	[EUR ha^{-1}]	-1.388	-0.571	-1.388	-0.571

Notes: --: no value, no symbol

Table 3.2-7 presents the production data and the model results for the example PMP model for a farm with 1000 ha UAA and the two agricultural activities wheat production of 700 ha and oats production of 300 ha. The assumed production, price and policy data are given for the calibration scenario I and the simulation scenario II. Subsidies for wheat and oat

production in scenario I are for both 300 EUR per ha. In the simulation scenario II the subsidies for the activities wheat and oat production are reduced by 50% to 150 EUR per ha.
In scenario II the average gross margin for oats becomes negative with -50EUR ha^{-1}, i.e. the costs are higher than the revenue, which makes the production of oat not profitable. Thus it would be rational if the farm would not produce oats at all. However, the model reacts with still an extension of oats activity by 62 ha. Since the acreage of wheat production is only 602 ha (compared to the 700 ha in scenario I) the total land used for production of wheat and oats is 664 ha and 336 ha are converted into abandoned UAA.
Figure 3.2-1 illustrates the above mentioned model reaction by the marginal gross margin (MGM) functions. In scenario I the intercepts and the slopes of the MGM functions result in an equal MGM of 14.3 in the reference acreage. Reducing the subsidies by 50% in scenario II means that the intercepts are decreased for wheat and oats by 150 EUR ha^{-1} (to 836 and 36 EUR ha^{-1}). Keeping the same slope the functions are not intersecting each other but they intersect the X-axis in a MGM of approximately zero. The area in between the intersections of the MGM functions represents the abandoned UAA of 336 ha.
This example illustrates that the flexibility of a PMP model is not sufficient to react to extreme changes of parameters which determine the profitability of the activities. In reality it could be expected that the area would still be used instead of falling out of production. Also in ACRE the reduction of subsidies in the study scenarios SUBred60% and SUBshift70% result in such effects of land abandoning. The most extreme effects are found e.g. in extensive counties where the profitability of crop production is reduced drastically because of small productivity and small gross margins.
The example calculated describes the reactions of a PMP model in changing the extents of production activities. The smooth adaptation reactions result from the optimum condition of equal marginal gross margins, i.e. the optimum exists when the marginal gross margins of each activity are equal. This let the PMP model find an optimal solution in discrete way by finding an optimum without defined restriction of activity extensions, which is in LP models the case. The reactions at regional level are expected to be rather smooth due to adding up the results of many regional decision makers. Thus, PMP models are regarded to be adequate to model agricultural production at regional level. However, the example calculated demonstrates that the PMP approach does not result in economical reasonable solutions if the changes of parameters are too extreme.

Figure 3.2-1: Reaction of the marginal gross margin functions of the example model in both scenarios.



Notes: MGM-PMP I wheat: marginal gross margin function of the PMP model in scenario I for wheat; MGM-PMP II oats: marginal gross margin function of the PMP model in scenario II for oats.

Regional farm approach and land markets

The regional farm approach aggregates all production factors of a NUTS3 county and optimizes agricultural production as it would be one single farm. This approach implies an 'error of aggregation'. The error of aggregation results from not considering that in reality the production factors are allocated to individual farms. Thus the assumption of one single farm (the regional farm) allows the ACRE model to optimize production by using the total resources, which are in reality allocated in the same county for example to farm 1 and 2. The regional farm model is allowed to extend within the county an activity A on the total resource (land), although in reality the land belongs to farm 2 which produces in reality only activity B. Thus, the projected optimized combination of activities might be simplified and a different one in the regional farm model than it would be in reality.

Abandoned UAA is a set free resource of the production factor land, which is not used for optimization by the regional farm at NUTS3 county level. Thus the regional farm model lets UAA fall abandoned while in reality the resources that are set free from production in one regional farm could be used e.g. by the neighboring regional farm. Thus, a reallocation of land between the regional farms would not result in UAA falling abandoned (or at least not as much as without the possibility of land reallocation between the regional farms). This possibility of land reallocation has to be taken into account when looking at the scenario results, as in ACRE land allocation via a land market is not modelled.

Alternative production of energy crops

In ACRE the activities for agricultural production are restricted to activities which could be observed in the statistical data for the year 1999. The abandoning of UAA itself is less an activity in the sense of PMP than more a calculated residual from the sum of the activities (cf. Appendix 2.1). An alternative crop activity which's importance increased significantly since the year 2000 is the production of renewable energy crops. Energy crops can be produced on UAA and compete with other crops for the resource land. However this activity has not been implemented in ACRE in the subsidy reduction scenarios in order to investigate the impact of modified subsidies separately from assumptions of energy crop production.[43] Considering energy crop production would increase the demand for UAA and reduce the effect of land abandoning.

Policy recommendation

The analysis of the scenarios SUBred60% and SUBshift70% shows that positive and negative impacts are only slightly different in both scenarios.

Out of the two policy options SUBred60% might be more recommendable because application and administration of AEM are associated with high administrative costs. Thus, from these results a reduced flat rate payment from Pillar 1 without extension of the Pillar 2 could be recommended as it is suggested also by SABAP (2005: 11). However, it should be taken into account that limitations are given with regard to the modelling assumption of highly increasing price development, the effect of abandoning of UAA as well as the not full representation of all AEM.

[43] The simulation of energy crop production separately is presented in Section 3.3, while the simulation of modified subsidies together with energy crop production is described in Section 3.6.

3.3 Energy crop scenario

This chapter describes the simulation of scenarios which consider the objective of increased production of energy crops. Two scenarios are analysed: one scenario in which energy crop production competes weakly with other agricultural activities, and another scenario with the assumption of strong competition between energy crop and food production. The simulations are done by using different calibration parameters for the energy crop activity. In Subsection 3.3.1 the scenario background and in Subsection 3.3.2 the scenario assumptions are described. The modelling of the scenario is delineated in Subsection 3.3.3. The Subsection 3.3.4 and 3.3.5 present the analysis of the results according to NUTS3 counties as well as according to farm types. A final scenario discussion is given in Subsection 3.3.6.

3.3.1 Scenario background

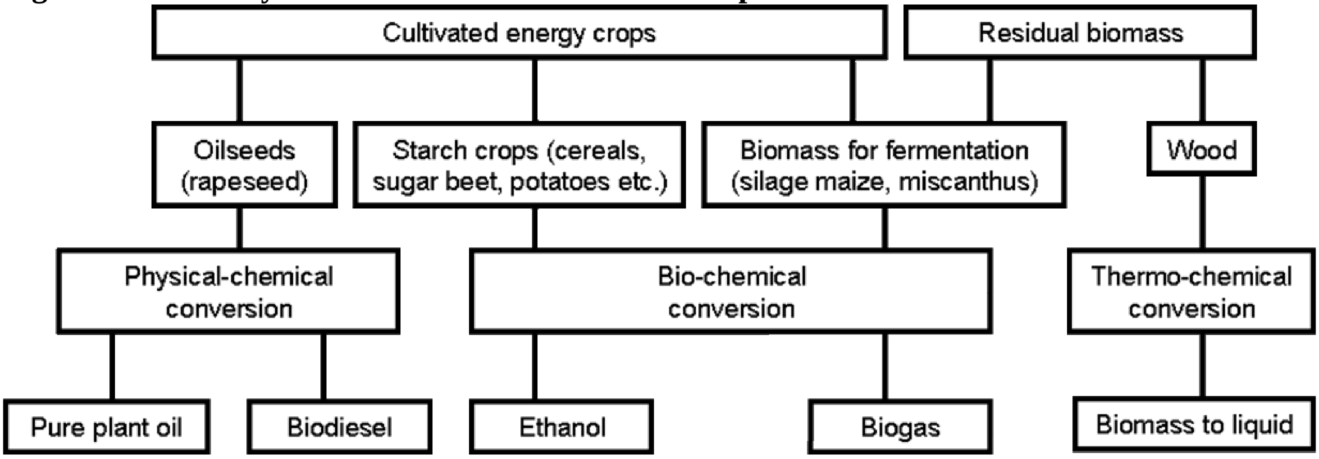
This section gives a brief overview of the energetic use of crops and introduces the main and specific objectives of bioenergy policies in the EU, Germany and in Baden-Wuerttemberg.

Energetic use of crop products and biomass

A lot of political and scientific discussions currently deal with the necessity of using renewable energy resources, which include solar and wind power, hydroelectricity, energy from biomass and biofuels (e.g. Breuer and Holm-Müller 2006, Filler et al. 2007, Gömann et al. 2007, SABAP 2007, Blanco et al. 2010).

Figure 3.3-1presents the systematics of the production chain required for production of biomass and biofuels according to Arnold et al. (2005). For agricultural production the cultivated energy crops are of high importance including rapeseed, starch containing crops (wheat, sugar beet etc.) and biomass crops (e.g. silage maize).

Figure 3.3-1: The systematics of biomass and biofuels production.



Source: Arnold et al. (2005: 2)

Main objectives of bioenergy policy

The production and use of bioenergy is a topic of interest of policy world wide, at European and national level as well as regionally (i.e. Baden-Wuerttemberg). Since the 1990s the EU promotes the production of renewable energy technology programmes or specific policy initiatives. The three basic objectives of the policy promoting production of bioenergy from renewable crops are (see e.g. EC 2006A, BMVEL 2008A, MRL 2006):

- the security of energy supply by increasing the share of bioenergy in the energy mix,
- climate protection by reduction of greenhouse gas emissions,
- to establish production of bioenergy as a new production alternative for the agricultural sector.

Security of energy supply

The production of renewable energy contributes to the security of energy supply in several ways. It enlarges the share of domestically produced energy and diversifies the domestic energy mix. The diversification of Europe's energy supply should increase the share of renewable energy and reducing reliance on imported energy (EC 2005B: 8). However, when bioenergy production should be increased then the competitive supply and environmental objectives have to be considered: production according to good agricultural practice, safeguarding sustainable production of biomass and without significantly affecting domestic food production (EC 2005B: 5).

Reduction of greenhouse gas emissions

The European Environment Council decided on 10 March 2005 that developed countries should reduce the pathways of GHG emissions by 15 to 30% by 2020 compared to the base year 1990 envisaged in the Kyoto Protocol (EC 2006A: 14). A cornerstone in the overall EU policy for reducing GHG emissions is the policy on renewable energies (EC 2006A: 9). Significant reductions of CO_2 emissions by replacing fossil energy with bioenergy are expected especially in the electricity sector (EC 2006A: 14).

Production alternative

The production of renewable energy and the necessary raw material (e.g. biomass, oilseeds) is expected to become an alternative branch of production for farmers. Thus, for agricultural producers the energy market becomes an additional market to the food and fibre market. Serving as "energy farmers" offers an alternative income source and thus contributes positively to the objectives of rural development policies.

Specific bioenergy policies at EU, German and Baden-Wuerttemberg level

Bioenergy policy at EU level

In order to reach the overall objective of increasing the production and usage of renewable energies, specific targets have been formulated and partially quantified at EU level. The EU defined the "desirable and feasible target" to reach by 2020 a share of 20% renewable energy of consumed energy (EC 2006A: 10) by aiming at following sub objectives:

- the share of renewable energies in the energy mix should be doubled from 6% to 12% by 2010 (White paper COM 599/1997), biomass energy should contribute by a share of 75 % (MLR 2006: 4).
- the share of biofuel consumption of total transport fuels should be increased to 5.75 % in 2010 (Directive 2003/30/EC) and to 10% in 2020 (MLR 2006: 4).
- the share of electricity from renewable resources on total electricity in EU should be increased to 22% by 2010 (Directive 2001/77/EG, MLR 2006: 4). The Member States committed themselves to national targets for electricity from renewable energy (EC 2005B: 8).

The biomass energy targets are supported by the CAP by the usage of three policy measures EC (2005B: 13): (1) Decoupling of direct payments allow farmers to respond to a demand of energy crops. (2) Special aids of 45 EUR ha^{-1} for energy crops give additional incentive to produce energy crops. (3) Allowing farmers to use mandatory set-aside land for growing non-food crops (including energy crops).

Bioenergy policy at national level in Germany

The German government set the objective to increase the use of bioenergy (BMVEL 2008A) and a national instrument for the promotion of renewable energies is the "Erneuerbare Energien Gesetz" (EEG). This law regulates the supply and prices for electricity from renewable resources, it was published in April 2000 and reformed in August 2004 (Filler, et al. 2007: 178). The production of energy from renewable energy crops is subsidised by tariffs for feed-in electricity. The price was e.g. in 2006 about 0.17 EUR kWh^{-1} and thus 0.12 EUR kWh^{-1} higher than for conventional energy (Gömann et al. 2007: 264). The most relevant energy crop in Germany is energy maize, which shows as the most profitable biomass crop the highest increase of UAA (Gömann et al. 2007: 264).

Bioenergy policy at regional level in the study region Baden-Wuerttemberg

At regional level the federal state Baden-Wuerttemberg published a biomass action plan which defines its economic, supply and environmental objectives of bioenergy policy drawn on the EU policy objectives (MLR 2006: 4 ff):

- economic objectives: promotion of agricultural production, forestry and industry in rural areas;
- supply objectives: contribution to future energy mix; reduction of dependency from the import of energy
- environmental objectives: reduction of CO_2 emissions; economic and ecological reasonable usages of renewable resources.

Development of energy crop production in Baden-Wuerttemberg

The focus of regional bioenergy production in Baden-Wuerttemberg lies on using biomass from wood and on biogas production (MLR 2006: 4). The energy crops mainly produced are winter rapeseed for biodiesel (Rapsmethylester) and silage maize for the production of biogas and as raw material for bioethanol. The estimated arable land used for energy maize production was in 2005 about 5% of total arable land (i.e. 2.9% of UAA). Arable land that is set-free from fodder production and set-aside can increase the area for energy crop production up to 10% to 15% of UAA (MLR 2006: 6).

Agricultural production statistics of Baden-Wuerttemberg show a significantly increasing trend of silage maize area used for biogas production in the last years (Hartmann 2007: 41).

Table 3.3-1 presents the acreages of arable crops in the year 2006, as well as the acreage of selected energy crops and their share of arable crop land and of UAA. With 7% of UAA energy maize was the arable crop with the third largest acreage after winter barley (8% of UAA) and winter wheat (15% of UAA). The acreage of silage maize for energy use is with 5,985 ha 6.3% of the total silage maize area. The share of the other arable crops used for energy production is with less than 2% significantly smaller.

Table 3.3-1: Acreages and percentage UAA in 2007 in Baden-Wuerttemberg.

	Acreage of arable crops	Acreages of energy crops			Acreages of arable crops (including energy crops)		
	ha	% of arable land	% UAA^{g}	% of corresponding crop acreage		% of arable land	% UAA^{g}
Renewables	26987	3.37	1.96				
Energy Crops	8463	1.06	0.61				
Total	35450	4.43	2.57				
Winter wheat	621 [c]	0.08	0.05	0.3	208273	26.03	15.10
Winter barley	145 [e]	0.02	0.01	0.13	111196	13.90	8.06
Energy maize	5985 [a]	0.75	0.43	6.25	95813	11.98	6.95
Spring barley					86004	10.75	6.24
Winter rapeseed	213 [b]	0.03	0.02	0.28	75142	9.39	5.45
Grain maize					54694	6.84	3.97
Fallow					37146	4.64	2.69
Clover					30816	3.85	2.23
Oats					27318	3.41	1.98
Triticale	391 [d]	0.05	0.03	1.86	20992	2.62	1.52
Sugar beet					19822	2.48	1.44
Vegetables, strawberries, horticultural crops					10467	1.31	0.76
Dinkel					10571	1.32	0.77
Rye					11780	1.47	0.85
Sum					800034	100	58

Noes: a) including silage maize-sunflower mixture, CCM, maize Cob. b) including winter rapeseed-Gp. b) including winter winter wheat-Gp. d) including triticale-rye mixtures, Triticale-Gp, Triticale-barley-Gp. e) including barley-GP, Sudan gras, Raygras. f) including grass, clover and clover-grass. g) calculated by % of arable land * 58%. Arable land is 58% of UAA

Source: own calculations based on Hartmann (2007: 41)

The data illustrate that silage maize is the energy crop in the region Baden-Wuerttemberg with the largest acreage. Due to the regional importance of silage maize for energetic use the energy crop production is simulated in this chapter by energy maize production as the representative energy crop. The production activity of energy maize is defined as the same production activity as for silage maize. In contrast to silage maize energy maize it is not used for feeding but sold as raw material for energy production from biomass. Thus, the energy maize is categorized as cash crop to be sold as commodity, not as fodder crop as to silage maize.

3.3.2 Scenario assumptions

The future development of energy crop production is difficult to project due to uncertainties in development of the oil price, the prices of agricultural commodities (and the food market), the technological progress (in the biofuel production) as well as in the developments of CO_2 emissions from the different pathways (Wiesenthal and Schade 2010).

Impacts on agricultural markets resulting from energy crop production are partially expected to be ambivalent. On the one hand a promotion of energy crop production is evaluated as positive with respect to employment, as an alternative branch of agriculture production. It is expected that energy maize production can compete with other crops and that this new production alternative results in the creation of new jobs in rural areas (BMELV 2008A). On the other hand promotion of energy crop production is evaluated as negative with respect to food production and thus for the employment in agricultural food production. It is expected that energy maize production and increased food demand results in higher competition between these production alternatives and provokes decrease of livestock production and the associated jobs (SABAP 2007). The different degrees of competition between the production activity of energy crops and food and fodder crops let define different scenario assumptions in the study at hand. In order to capture the ambivalent assumptions, the following two scenarios are assumed: (1) The energy crop production is only weakly competitive compared to other production activities, and therefore energy crops do not replace other crops from the scarce factor arable land. (2) The energy crop production is highly competitive compared to other production activities and therefore energy crops replace large areas of other crops from the scarce factor arable land.

3.3.3 Scenario modelling

To simulate energy maize production activity with the different competition assumptions energy maize production activity is calibrated with different parameters. For the weak competition scenario (EmaizeSM) the assumption is that the competition of energy maize is similar to silage maize sold as cash crop. For the scenario with high competitive energy maize (EmaizeWW) the assumption is that energy maize competes directly with the major crop, which in the model regions is winter wheat.

Calibration parameter of energy maize activity functions

In this study agricultural crop activities are simulated by non-linear production functions which are calibrated according to the PMP method. [44] For the calibration of the PMP model including energy maize production activity regional statistical production data of the year 1999 were not available because the Statistical Office of Baden-Wuerttemberg did not survey the production data of energy crops at this time.[45] Thus the modelling of energy maize activity according to the standard method of PMP is not possible and raises the necessity for an alternative way of implementing an energy maize production activity in a PMP model. The introduction of a new production activity into the optimization model requires adding a new non-linear function of the new activity to the existing activities. In the PMP approach the non-linear functions are defined by parameters, which are determined by the shadow prices calculated from the statistical data. Shadow prices represent the monetary value by which the total gross margin is increased when extending the activity by one further unit. Thus, the shadow prices of the activities reflect the economic competition between the crop production activities with respect to the scarce production factor arable land. Since representative shadow prices cannot be derived from statistical data for building non-linear functions for new production activities, it is necessary to use parameters that represent the shadow prices (proxy parameters).

In order to introduce the energy maize activity and to simulate the energy crop scenarios a method was used derived from Göman et al. (2007: 266). Göman et al. (2007) used in their study the shadow prices of the major cereals winter wheat and winter barley to calculate non-linear parameters for representing energy maize production. They calculated parameters from the average of both cereals to calibrate the non-linear function of energy maize production assuming that these the average parameters of the major crops represents a similar competitiveness as energy crop production.

In this study the shadow prices from the two crops silage maize and winter wheat are used separately to calculate parameters which simulate two scenarios in which energy maize is of different competitiveness: for small competitiveness with food production the shadow prices from silage maize are used, for high competitiveness with food production the shadow prices of winter wheat are used.

[44] Reminder: The PMP method requires empirical data to formulate the LP calibration model. The LP calibration model calculates shadow prices by historical data of acreages, yields, market, subsidies and production costs. These shadow prices are used to calculate the slope of the non-linear gross margin function in the objective function (cf. Section 2.3.3 and 3.2.7).

[45] Due to the increased relevance of energy crops the recent data collections of regional data on NUTS3 level include also data on acreage of energy crops.

Production costs, subsidies and the derivation of producer prices

Assuming that the production process of energy maize is quite close to the production process of silage maize the energy maize yields data and production costs are represented by the corresponding regional data of silage maize. Energy maize production is entitled to the payment of 45 EUR ha^{-1} according to the CAP 2003 reform (i.e. before the CAP Health Check in 2008).

In order to simulate a competitive situation between energy maize and other arable crops the producer price has to be defined in the scenarios in a way that it results in a comparable relative increase of gross margin of the major crop and of energy maize. The benchmark for the gross margin is given by the major arable crop winter wheat. A sensitivity analysis has been done in order to identify the price that results in a similar percentage increase compared to the reference year as for winter wheat. The reference gross margin for energy maize is defined by the regional reference costs and yields for silage maize as well as by the price of 2.50 EUR dt^{-1} for energy maize (cf. Table 3.3-2). Subsidies are not considered in this calculation. Table 3.3-2 presents the percentage changes in gross margin of winter wheat and of energy maize depending on different price assumptions. The values are selected values for 12 selected representative counties for the farm types AL-CC, AL-FC, GL-IG and GL-EG. Thus, gross margins in the counties are determined by regional crop yields, costs and prices and their development in the scenario year 2015. The percentage increase of winter wheat gross margin in the scenario year 2015 ranges from 179% in county UL to 309% in county KA. Assuming a price of 4.50 EUR dt^{-1} the relative increase of energy maize gross margin ranges from 229% to 329%. This percentage increase is comparable with the increase of gross margin of winter wheat.

In order to evaluate the plausibility of the selected energy maize price of 4.50 EUR dt^{-1} different studies that published prices for bioenergy crops in different regions in Germany have been reviewed (cf. Table 3.3-3). For example Breuer and Holm-Müller (2006) calculated prices for different energy crops for their calculations in the Federal state Nordrhein-Westfalia. Bahrs and Waßmuß (2006) calculated the minimum prices for energy price for different regions of Northern Germany. In Table 3.3-3 prices published in selected studies are listed, and it can be seen that in this studies the price for energy maize ranges from 1.85 EUR dt^{-1} to 6 EUR dt^{-1}. The selected price for the study at hand is with 4.50 EUR ha^{-1} in the price range published by Schmid and Dederer (2006: 7-8). Considering that the wheat price increases highly, a high price for energy maize can also be expected and thus, it is plausible to assume one of the higher prices published for energy maize.

Table 3.3-2: Percentage deviation of crop gross margin between reference situation and baseline scenario in selected counties.

			Producer price EUR dt^{-1}						
		Producer price of energy maize:	2.00	2.50	3.00	3.50	4.00	4.50	5.00
		Development of regional gross margin of winter wheat	Development of regional gross margin of energy maize under different producer price assumptions						
Farm type	County-ID	%	%						
AL-CC	HN	270	-86	-19	49	116	184	251	319
AL-CC	TBB	207	-80	-17	46	108	171	234	297
AL-CC	KA	309	-91	-20	52	123	194	266	337
AL-FC	KN	268	-81	-17	46	110	174	238	302
AL-FC	UL	179	-78	-17	45	106	168	229	290
AL-FC	BC	180	-80	-17	45	108	171	233	296
GL-IG	FR	293	-89	-19	50	120	189	258	328
GL-IG	LOE	1175**	-83	-18	47	112	177	242	307
GL-IG	RV	191	-92	-20	52	124	197	269	341
GL-EG	TUT	214	-83	-18	47	113	178	243	309
GL-EG	RT	258	-82	-18	47	111	175	240	304
GL-EG	BL	301	-113	-25	63	152	240	329	417

Notes: ** unreliable value

regional reference $GM_{energy\ maize}$ = regional reference $yield_{silage\ maize}$ * 2.50 EUR dt^{-1} – regional reference $costs_{silage\ maize}$

regional reference $GM_{winter\ wheat}$ = regional reference $yield_{winter\ wheat}$ * 11.60 EUR dt^{-1} – regional reference $costs_{winter\ wheat}$

Notes: CC mainly cash crops, FC mainly fodder crops, GE extensive grassland IG intensive grassland.

Table 3.3-3: Producer prices for biomass crops according to selected sources/authors.

Product	Price in EUR per dt	Source
Silage maize	1.85	Arman (2003: 65)
Energy maize	2.00	Breuer and Holm-Müller (2006: 161)
Biomass maize	5.00 – 6.00	Schmid and Dederer (2006: 7-8)
Silage maize	2.10	Breuer and Holm-Müller (2006: 161)
Energy maize	1.70 – 2.30 [a]	Bahrs and Waßmuß (2006)
Biomass maize	2.10 – 2.50	Bundesgütegemeinschaft Kompost e.V. (2006)
Biomass maize	1.94-2.81	Landwirtschaftliches Wochenblatt (2007: 36)

[a] Minimum prices to replace winter barley, winter wheat, rye or triticale

Source: own compilation

3.3.4 Analysis of indicator values according to the NUTS3 counties

This section describes the development and the status of the economic, supply and environmental indicator values. The analysis has been done at regional level for the NUTS3 counties where agricultural production is represented by 'regional farms' for the scenario with a small competitiveness between energy maize and food production (EmaizeSM) and a strong competitiveness between energy maize and food production (EmaizeWW). The development of indicator values is compared with the development of indicator values in the baseline scenario CAP2003.

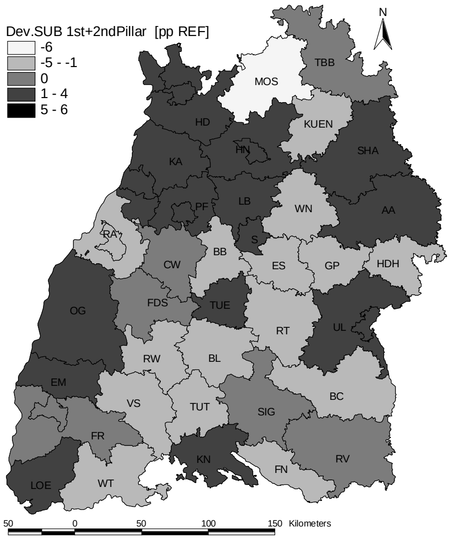
Development of economic indicator values

In both scenarios the changes of the total subsidy volume are small with decreases up to 6pp (cf. Map 3.3-1 a to b). In counties with 6pp decrease the reduction of extensive grassland and intercrop area results in a decrease of payments from Pillar 2. Extensive grassland is shifted to arable land or intensive grassland to compensate for losses of fodder area. The intercrop area decreases because intercropping is not defined for area with maize production.

In several arable districts the special aid for energy crops of 45 EUR ha^{-1} compensates for the loss of subsidy volume from Pillar 2 payments. This happens in arable counties that increase the area of energy maize, as in Bessere Rheinebene, in Unterland and in Schwäbischer Wald, Hohenlohe. The distribution of average subsidies is similar in both scenarios (cf. Map 3.3-1 c to d).

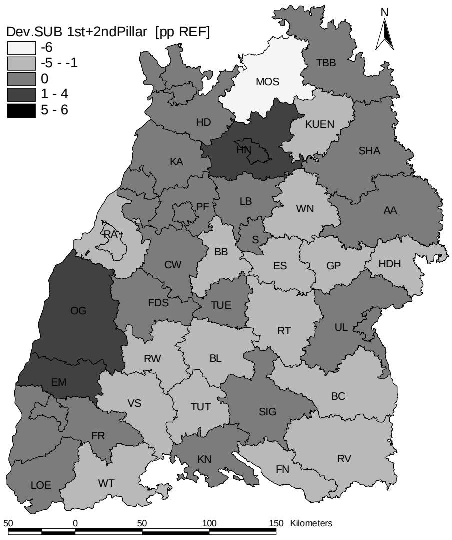
In both scenarios regional TGM differs only slightly from the CAP2003 scenario (Map 3.1-1 e to f). Counties where energy maize replaces cereals area (i.e. HD, HN, LB, BB) lose 6pp to 12pp in total gross margin. This results from a reduced animal production. Cereals are used in these cash crop counties as fodder for bulls fattening. Replacing fodder cereals by energy maize results in a decreases of fodder and decreases of bulls stock. In extensive counties in Schwarzwald and in Schwäbische Alb less arable land is converted to grassland than in the CAP2003 scenario. Therefore, arable area for cereals and for maize production can be extended and the TGM increases. The distribution of average TGM is similar in both energy crop scenarios (Map 3.1-1 g to h).

Map 3.3-1 a: Percentage change of subsidy volume Pillar 1 and Pillar 2 in EmaizeSM compared to REF.



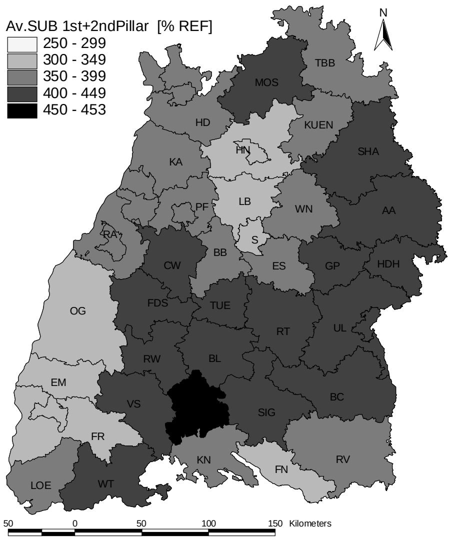
Note: Unit: %, basis: REF.

Map 3.3-1 b: Percentage change of subsidy volume Pillar 1 and Pillar 2 in EmaizeWW compared to REF.



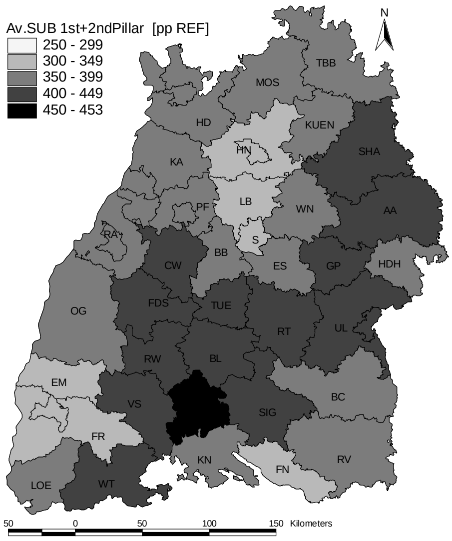
Note: Unit: %, basis: REF.

Map 3.3-1 c: Average Subsidies volume Pillar 1 and Pillar 2 in EmaizeSM.



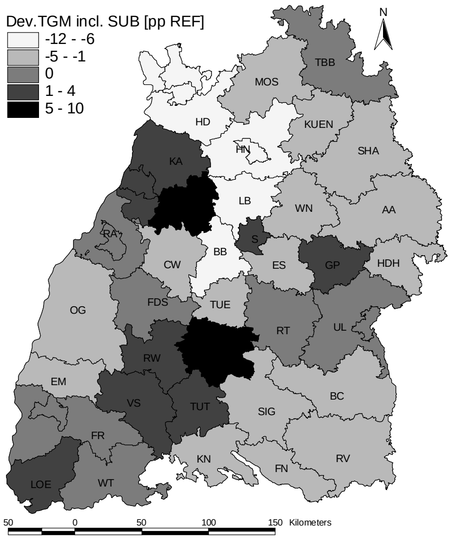
Note: Unit: %, basis: REF.

Map 3.3-1 d: Average Subsidies volume Pillar 1 and Pillar 2 in EmaizeWW.



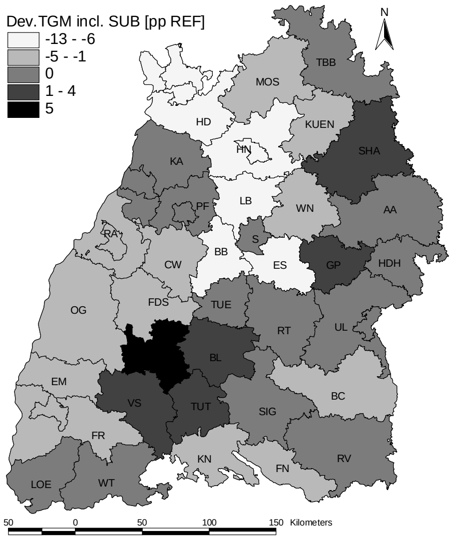
Note: Unit: %, basis: REF.

Map 3.3-1 e: Change of total TGM incl. SUB in EmaizeSM compared to CAP2003.



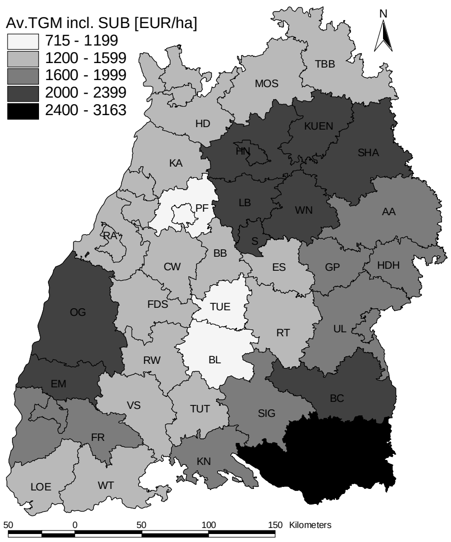
Note: Unit: pp, basis: REF.

Map 3.3-1 f: Change of total TGM incl. SUB in EmaizeWW compared to CAP2003.



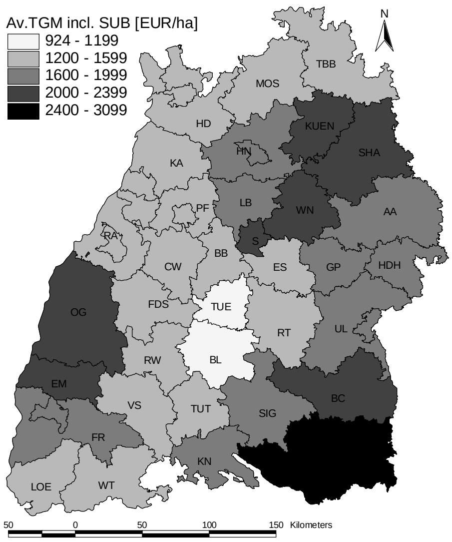
Note: Unit: pp, basis: REF.

Map 3.3-1 g: Average TGM incl. SUB in EmaizeSM.



Note: Unit: EUR ha^{-1}.

Map 3.3-1 h: Average TGM incl. SUB in EmaizeWW.



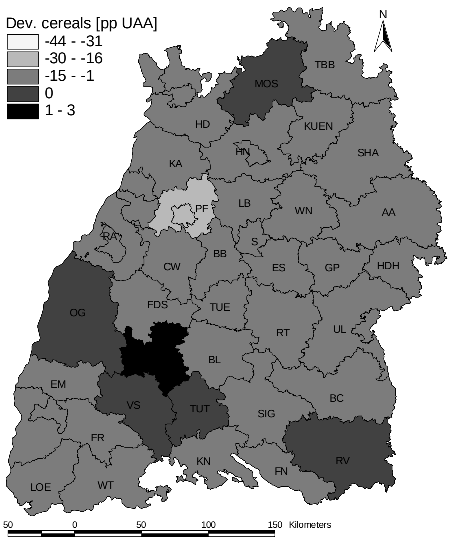
Note: Unit: EUR ha^{-1}.

Development of supply indicator values

Crop production

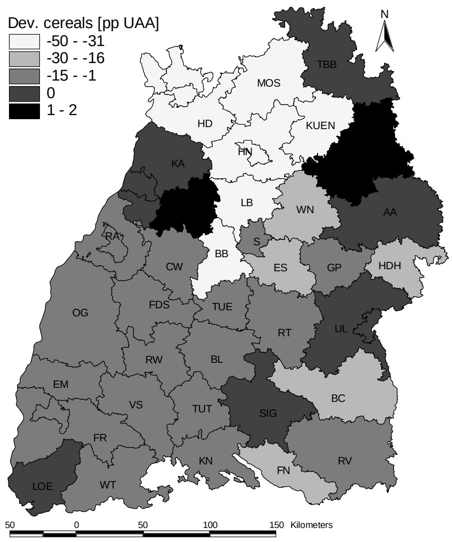
In both energy crop scenarios the cereal production is decreased in almost all counties. In EmaizeWW the reduction of cereal production is extreme in the counties in Unterland (e.g. MOS, HD, KUEN, HN, LB and BB) (cf. Map 3.3-2 a, b). In these counties the total maize area is extended (cf. Map 3.3-2 c, d). This increase in total maize area does not result from grain maize, which is decreasing or constant (cf. Map 3.3-2 e, f) but from energy maize which is increased significantly in both scenarios. The increase in energy maize area is more extreme and locally focussed in EmaizeWW (Map 3.3-2 g, h). In EmaizeSM the area of energy maize is smaller particularly in the south of the model region and energy maize production is less focussed in certain counties. The impact on fodder crop area is with -3pp to +1pp very small in both scenarios (cf. Map 3.3-2 j, i).

Map 3.3-2 a: Change in cereals area in EmaizeSM compared to CAP2003.



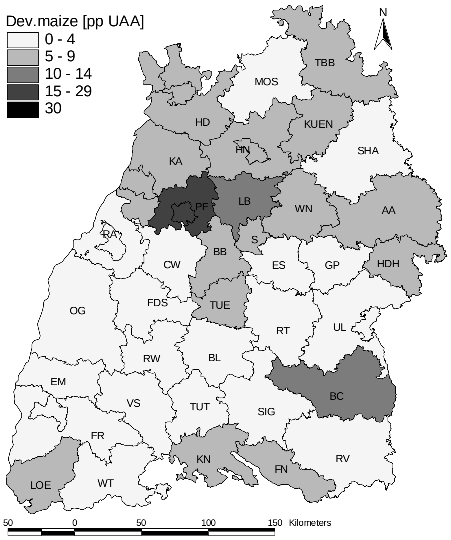
Note: Unit: pp UAA, basis: REF.

Map 3.3-2 b: Change in cereals area in EmaizeWW compared to CAP2003.



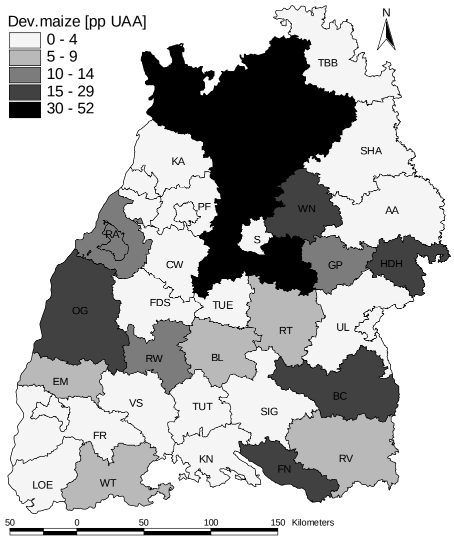
Note: Unit: pp UAA, basis: REF.

Map 3.3-2 c: Change in maize area in EmaizeSM compared to CAP2003.



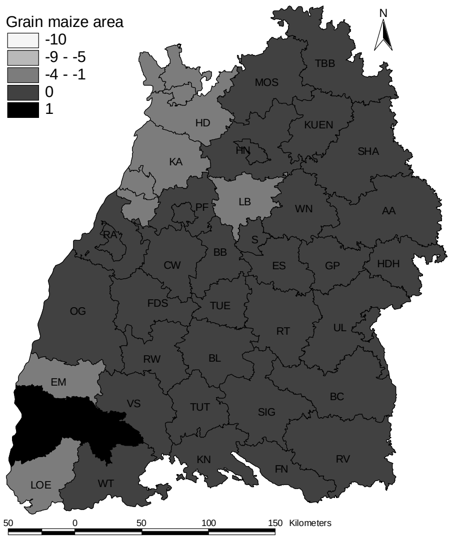
Note: Unit: pp UAA, basis: REF.

Map 3.3-2 d: Change in maize area in EmaizeWW compared to CAP2003.



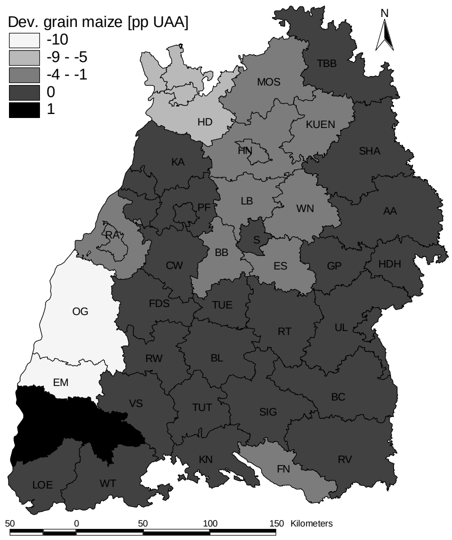
Note: Unit: pp UAA, basis: REF.

Map 3.3-2 e: Change in grain maize area in EmaizeSM compared to CAP2003.



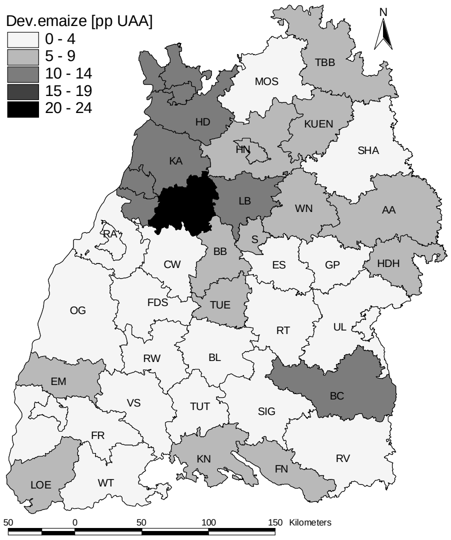
Note: Unit: pp UAA, basis: REF.

Map 3.3-2 f: Change in grain maize area in EmaizeWW compared to CAP2003.



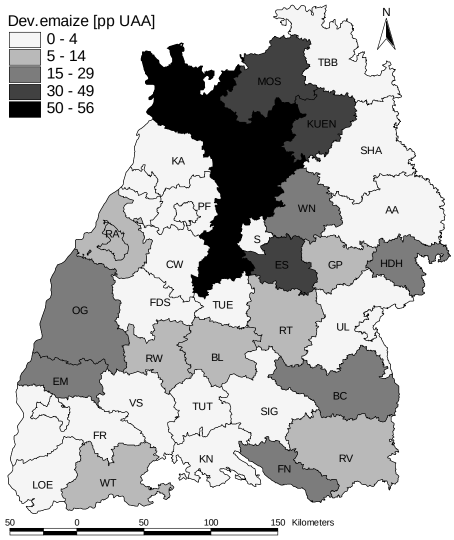
Note: Unit: pp UAA, basis: REF.

Map 3.3-2 g: Change in energy maize area in EmaizeSM compared to CAP2003.



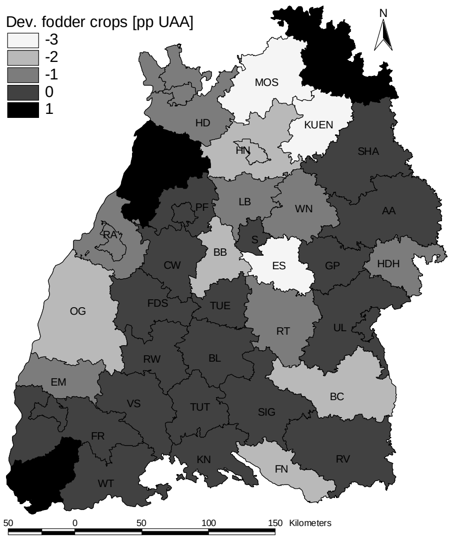
Note: Unit: pp UAA, basis: REF.

Map 3.3-2 h: Change in energy maize area in EmaizeWW compared to CAP2003.



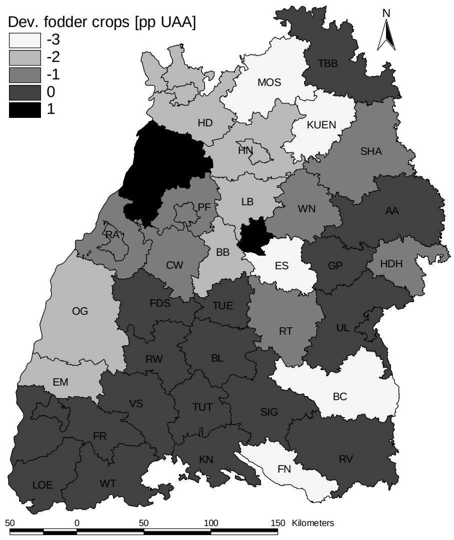
Note: Unit: pp UAA, basis: REF.

Map 3.3-2 i: Change in fodder crop area in EmaizeSM compared to CAP2003.



Note: Unit: pp UAA, basis: REF.

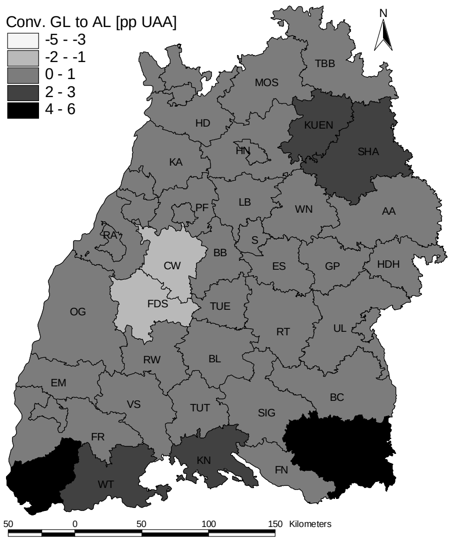
Map 3.3-2 j: Change in fodder crop area in EmaizeWW compared to CAP2003.



Note: Unit: pp UAA, basis: REF.

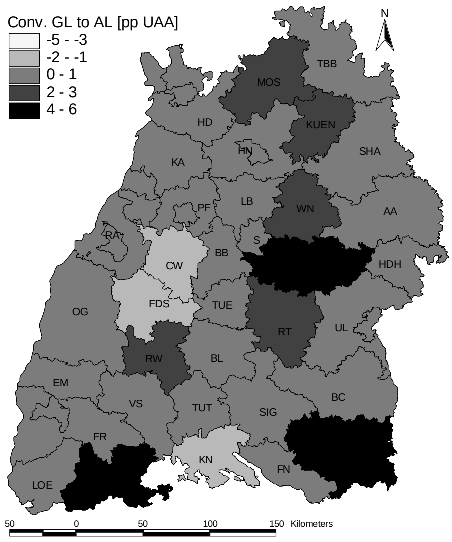
In both scenarios most of the counties keep grassland conversion constant and few counties convert grassland into arable land (e.g. KUEN, WT, cf. Map 3.3-2 k, l). Correspondingly the conversion from arable land into grassland is decreased. However a few extensive counties (CW, FDS) show a contrary development with slightly increasing grassland area. In the intensive grassland counties LOE and RV a slight reduction of intensive grassland can be observed (cf. Map 3.3-3 c, d).

Map 3.3-2 k: Change in GL converted into AL area in EmaizeSM compared to CAP2003.



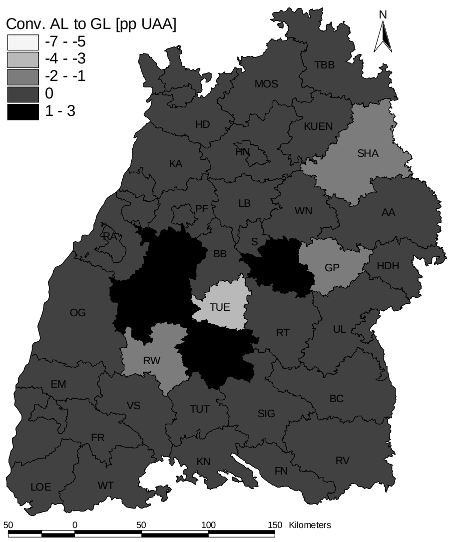
Note: Unit: pp UAA, basis: REF.

Map 3.3-2 l: Change GL converted into AL EmaizeWW compared to CAP2003.



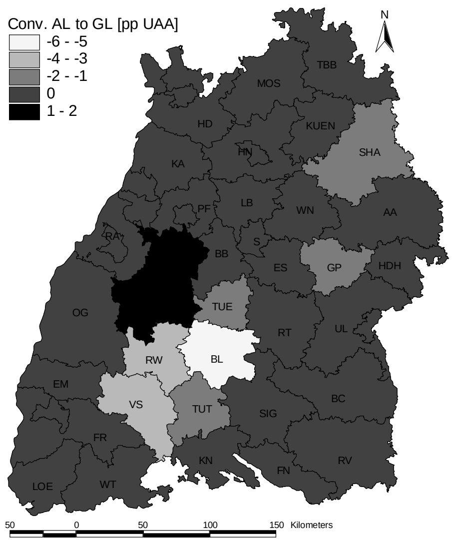
Note: Unit: pp UAA, basis: REF.

Map 3.3-2 m: Change in AL converted into GL area in EmaizeSM compared to CAP2003.



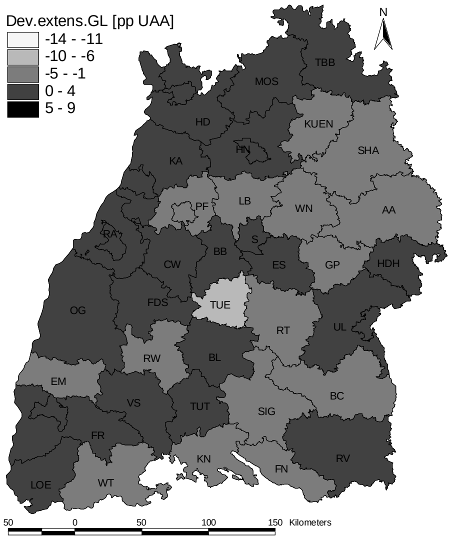
Note: Unit: pp UAA, basis: REF.

Map 3.3-2 n: Change AL converted into GL EmaizeWW compared to CAP2003.



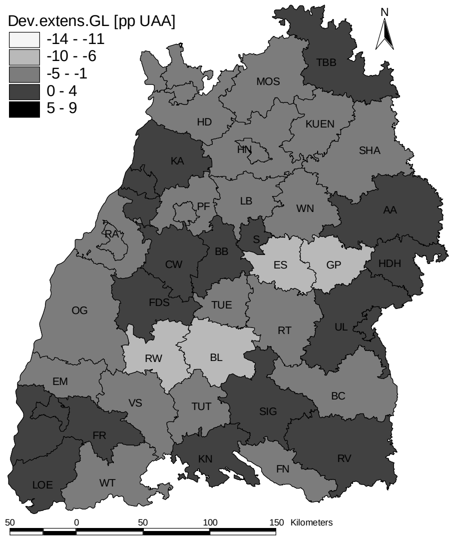
Note: Unit: pp UAA, basis: REF.

Map 3.3-3 a: Change extensive GL in EmaizeSM compared to CAP2003.



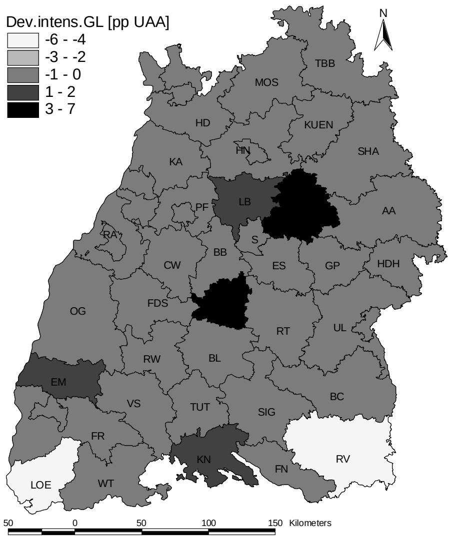
Note: Unit: pp UAA, basis: REF.

Map 3.3-3 b: Change extensive GL in EmaizeWW compared to CAP2003.



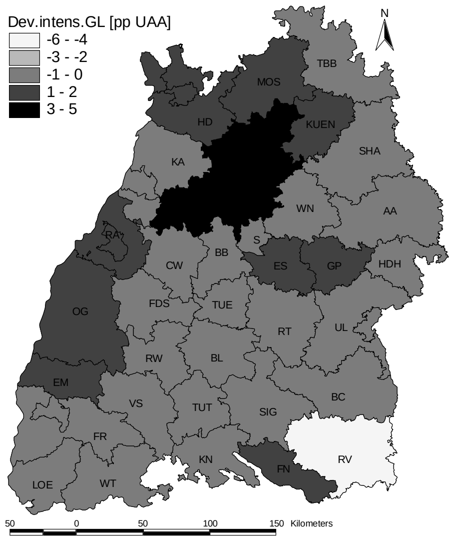
Note: Unit: pp UAA, basis: REF.

Map 3.3-3 c: Change intensive GL in EmaizeSM compared to CAP2003.



Note: Unit: pp UAA, basis: REF.

Map 3.3-3 d: Change intensive GL in EmaizeWWcompared to CAP2003.



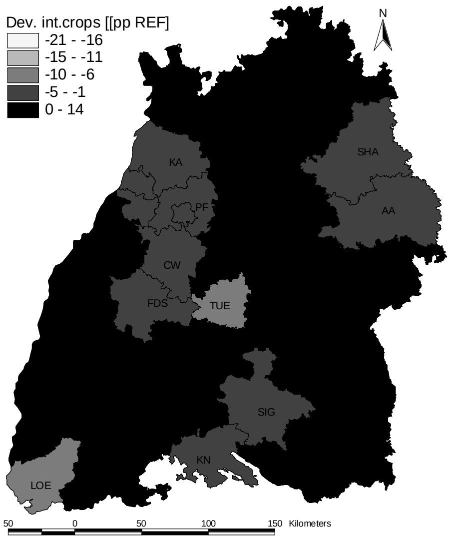
Note: Unit: pp UAA, basis: REF.

Crop production intensity and animal production

In both scenarios crop production intensity rises due to an increase of intensive crops area as a result of increased energy maize production and grassland conversion (cf. Map 3.3-4 a, b). In the counties SHA and AA the slight decrease of intensive crops area results from a decrease of converted grassland, while the extensification in KA, PF, CW and FDS is caused by decreases in intensive crops grain maize and oil seeds (cf. Map 3.3-4 c, d).

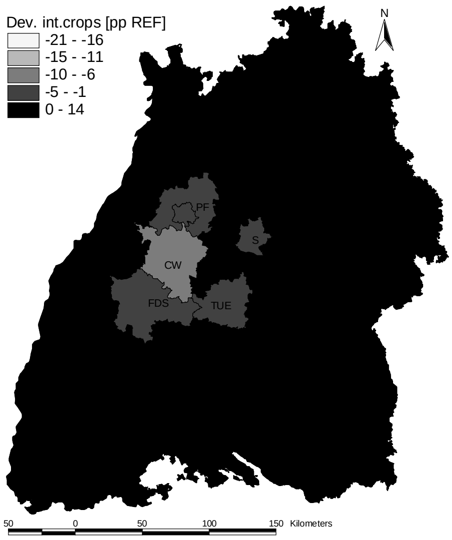
With respect to intensive variants area most of the counties show an extensification due to increase of extensive grassland. In the counties of Unterland the extension of intensive variants results from extensive grassland shifted to intensive grassland.

Map 3.3-4 a: Change intensive crop area in EmaizeSM compared to CAP2003.



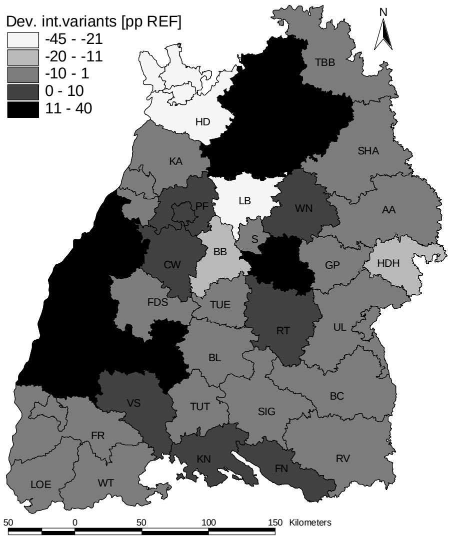
Note: Unit: pp UAA, basis: REF.

Map 3.3-4 b: Change of intensive crop area in EmaizeWW compared to CAP2003.



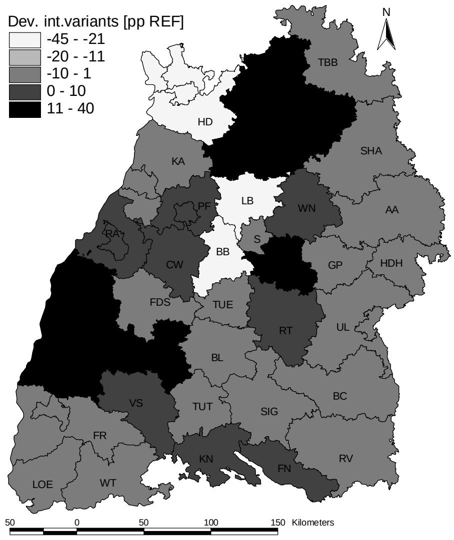
Note: Unit: pp UAA, basis: REF.

Map 3.3-4 c: Change intensive variant area in EmaizeSM compared to CAP2003.



Note: Unit: pp UAA, basis: REF.

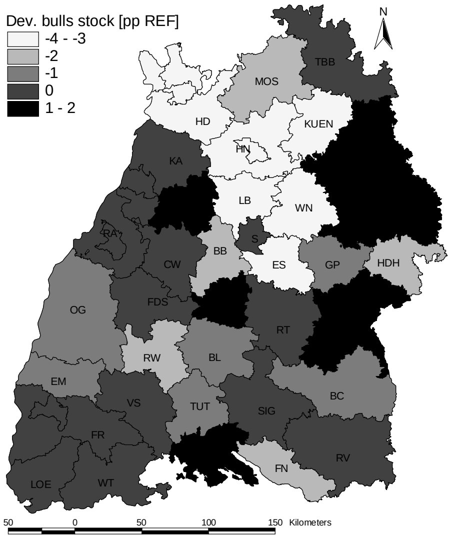
Map 3.3-4 d: Change of intensive variant area in EmaizeWW compared to CAP2003.



Note: Unit: pp UAA, basis: REF.

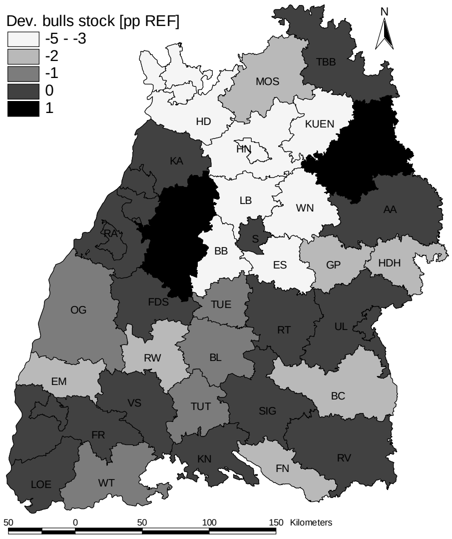
Bull stock is decreased at most in counties with high energy maize production in Unterland (cf. Map 3.3-5 a, b). Here, the replacement of fodder cereals and silage maize affects the bulls feeding activity. Absolute high decreases in bull stocks are projected for counties with initially high bull density and decreases in bulls density of 10 or more bulls per 100 ha, i.e. in EM, BC, HDH, GP (cf. Section 2.2).

Map 3.3-5 a: Change of bulls stock in EmaizeSM compared to CAP2003.



Note: Unit: pp UAA, basis: REF.

Map 3.3-5 b: Change of bulls stock in EmaizeWW compared to CAP2003.



Note: Unit: pp UAA, basis: REF.

Development of environmental indicator values

While an intensification in crop production can be detected in terms of increase of intensive crops and intensive variants, the nitrogen input tends to decrease in both energy crop scenarios. Demanded nitrogen for energy maize is with 144 kg ha^{-1} less than for the mainly replaced cereal winter wheat with 165 kg ha^{-1} (cf. Table 3.3-5). Thus, nitrogen intensity decreases due to reduction of demanded nitrogen particularly in Unterland, where energy maize area increased in both scenarios (cf. Map 3.3-6 a, b).

Table 3.3-4: Nitrogen demand for winter wheat and energy maize.

	Nitrogen base demand yield independent	Nitrogen demand yield dependent	Average yield	Demanded nitrogen
	kg N ha^{-1}	kg N dt^{-1} ha^{-1}	dt ha^{-1}	kg ha^{-1}
Winter wheat	0	2.5	66	165
Energy maize and silage maize	-40	0.4	460	144

Note: a) nitrogen demand which is needed to allow growing of the crop at all. For silage maize it is assumed that nitrogen from biomass of the previous crop is suffient to cover the basedemand of 40 kg N ha^{-1}

The environmental indicator of erosion potential shows a significant increase in both scenarios. Table 3.3-6 presents the erosion potential of different crops according to Schwertmann et al. (1987: 52). Maize has an erosion potential of 27.3% of uncovered arable land and it is with vegetables the most relevant crop for soil erosion. The total erosion potential increases significantly particularly in counties of Unterland.

Some countries show a decreasing tendency of erosion factor in the energy crop scenario. In Scenario EmaizeSM NUTS3 counties with decreasing tendency of the erosion factor are for example PF, with -65pp, TUE with -36pp and LOE with -41pp. This decreasing tendency results from a minor increase or even decrease in erosion potential in EmaizeSM, because the erosion potential compared to the reference year REF does not changes extremely. However, in the baseline scenario CAP2003 the counties show an extreme increase of erosion potential compared to the reference year REF. According to the calculation of the changes of indicator values (cf. Subsection 2.1.3 and Appendix 2.1) this results in a negative development.

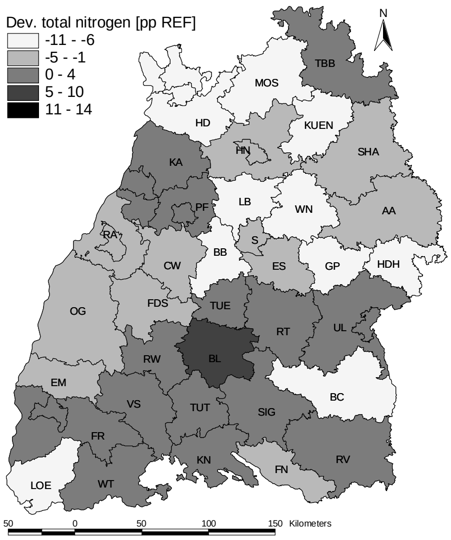
Table 3.3-5: Erosion potential of the crop activities.

Crop/landuse	% of uncovered arable land	Crop/landuse	% of uncovered arable land
Uncovered arable land	100.0	Spring barley	7.4
Vegetables	40.0	Winter wheat	6.8
Maize	27.3	Triticale	6.8
Potatoes	23.5	Oats	6.4
Sugar beet	21.3	Spring wheat	5.6
Winter rapeseed	11.2	Rye	4.9
Winter barley	9.3	Clover	1.0[a]
Sunflowers	8.0	Set-aside covered	0.0[a]
Legumes	8.0	Grassland	0.0[a]

[a] Own assumptions

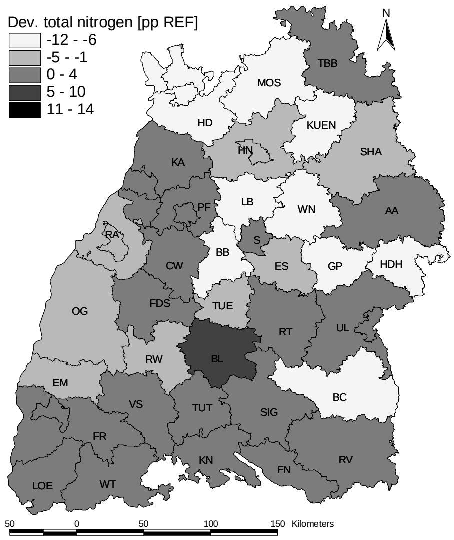
Source: Schwertmann et al. (1987: 52)

Map 3.3-6 a: Change of nitrogen input in EmaizeSM compared to CAP2003.



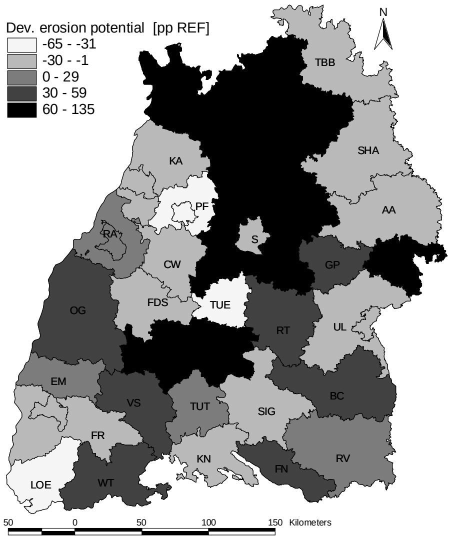
Note: Unit: %, basis: REF.

Map 3.3-6 b: Change of nitrogen input in EmaizeWW compared to CAP2003.



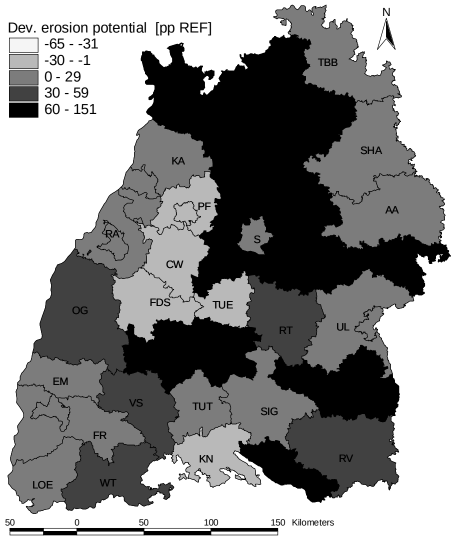
Note: Unit: %, basis: REF.

Map 3.3-6 c: Change of erosion potential in EmaizeSM compared to CAP2003.



Note: Unit: %, basis: REF.

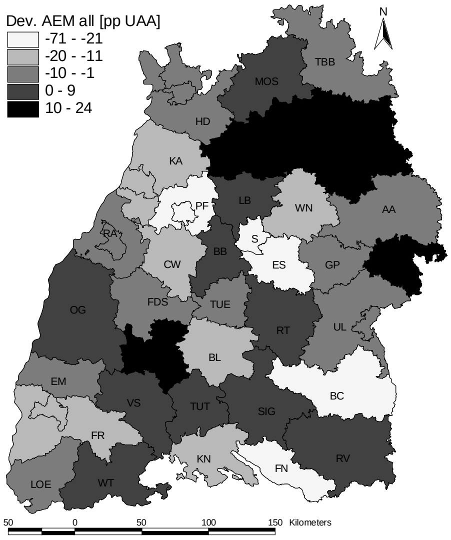
Map 3.3-6 d: Change of erosion potential in EmaizeWW compared to CAP2003.



Note: Unit: %, basis: REF.

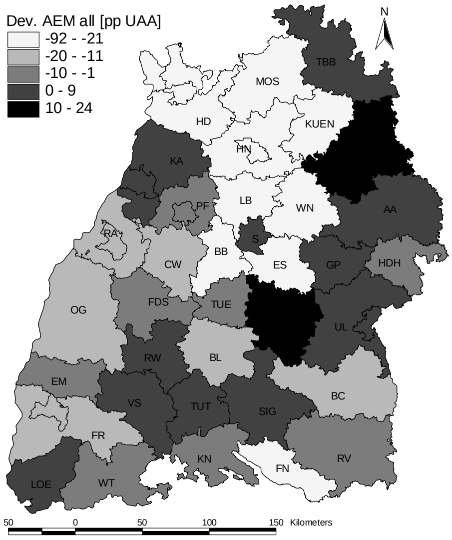
Potential AEM area tends to decrease in both scenarios due to intensification of production and extension of maize area (cf. Map 3.3-6 e, f). This development results particularly in the EmaizeWW scenario in a significant decrease of intercropping activities in counties with very large extension of energy maize production (cf. Map 3.3-6 g, h). Here, the weighted nitrogen intensity and the weighted erosion potential increase significantly according to the pattern of the real change of intercrops (cf. Map 3.3-6 i, j).

Map 3.3-6 e: Change of potential AEM area in EmaizeSM compared to CAP2003.



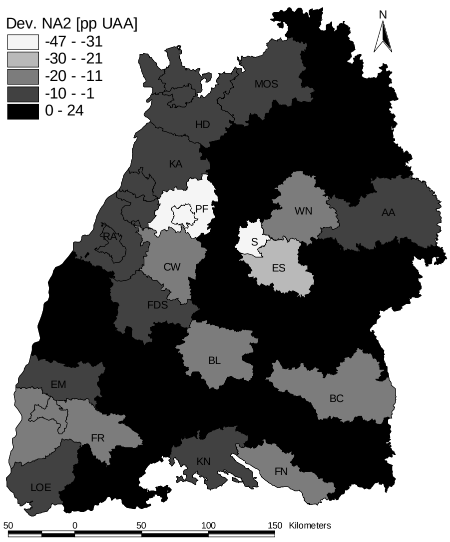
Note: Unit: pp, basis: REF.

Map 3.3-6 f: Change of potential AEM area in EmaizeWW compared to CAP2003.



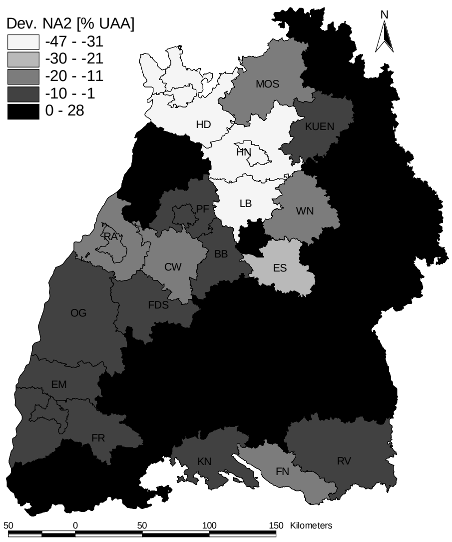
Note: Unit: pp, basis: REF.

Map 3.3-6 g: Change of potential NA2 (intercrops) area in EmaizeSM compared to CAP2003.



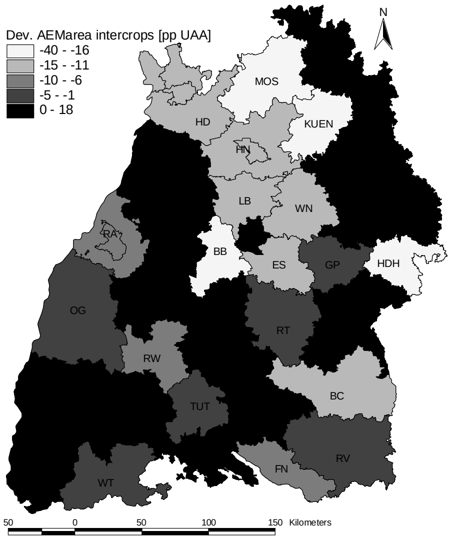
Note: Unit: %, basis: REF.

Map 3.3-1 h: Change of potential NA2 (intercrops) area in EmaizeWW compared to CAP2003.



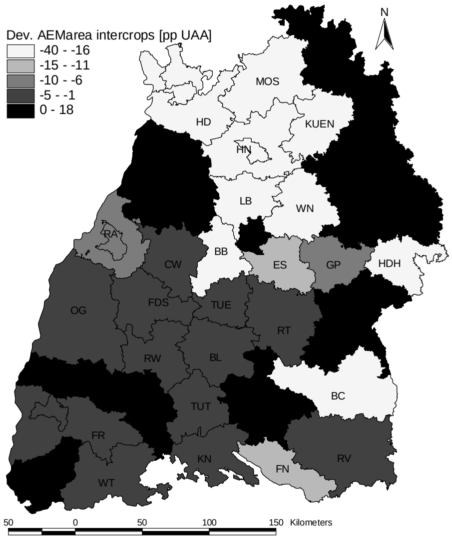
Note: Unit: %, basis: REF.

Map 3.3-6 i: Change of intercrop area in EmaizeSM compared to CAP2003.



Note: Unit: %, basis: REF.

Map 3.3-1 j: Change of intercrop area in EmaizeWW compared to CAP2003.



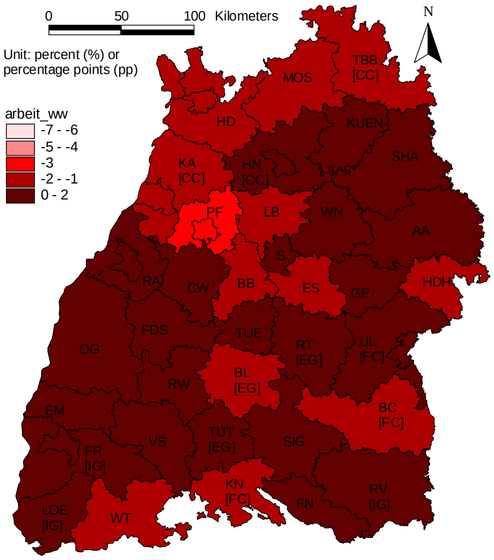
Note: Unit: %, basis: REF.

Indicator value: working hours

In order to analyse the impact of energy crop promotion on the policy objective of increasing alternative employment in the agricultural sector the development of working hours has been analysed as an additional indicator value. The analysis of this indicator value is added only in the energy crop scenarios, in order to compare the development of employment with the development which is expected by the study SABAP (2007) (cf. Subsection 3.3.2).

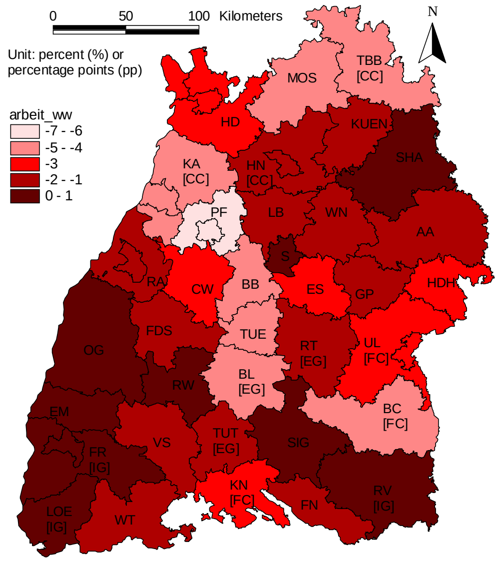
Map 3.3-7 a to d present the change in working hours in the scenarios EmaizSM and EmaizeWW and the development of bulls stock, which is the animal production activity most affected by energy maize production. In EmaizeSM bulls production and working hours are not affected significantly. However, the single counties with decreasing numbers of bulls (e.g. PF and WT) show also a decrease in working hours. In EmaizeWW the decrease of bulls is more extreme and most of the counties show negative development of working hours. Most counties in Unterland/Gäulandschaften and Oberland reduce bulls stock and working hours remarkably. Single counties (e.g. AA, WN) reduce their working hours less (-1 to -2%) even though the reduction of bull numbers is high. This effect results from a large absolute value for working hours in the baseline scenario CAP2003, for which even large absolute changes are indicated in relative small percentage change.

Map 3.3-7 a: Percentage development of working hours in EmaizeSM compared to CAP2003.



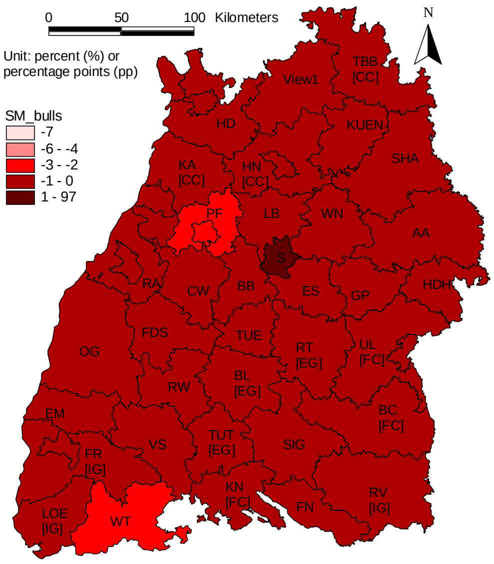
Note: Unit: %, basis: REF.

Map 3.3-7 b: Percentage development of work in EmaizeWW compared to CAP2003.



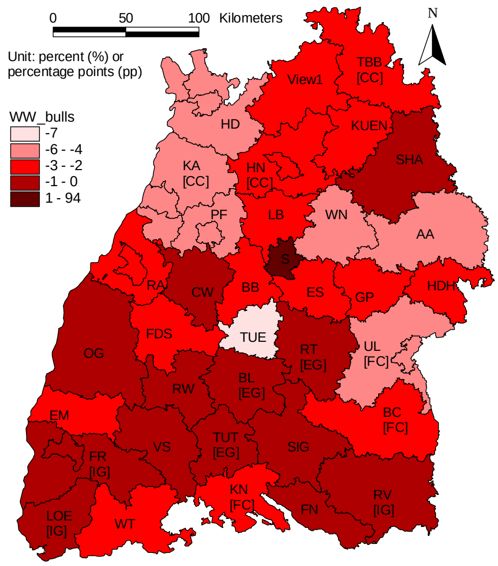
Note: Unit: %, basis: REF.

Map 3.3-7 c (repeated): Development of number of bulls in EmaizeSM compared to CAP2003.



Note: Unit: %, basis: REF.

Map 3.3-7 d (repeated): Development of number of bulls in EmaizeWW, in percentage points compared to CAP2003.



Note: Unit: %, basis: REF.

3.3.5 Analysis of indicator values according to farm types

Table 3.3-7 presents the development of the indicator values in farm types. In both scenarios the subsidy volume and agricultural income does not differ significantly from the baseline scenario CAP2003. The subsidies are reduced slightly because less arable land is converted into grassland, which means fewer payments for agri-environmental programs. Thus, the payments from Pillar 2 are changed significantly in AL-CC and AL-FC farm types.

Total gross margin decreases slightly in arable farm types in both scenarios because energy maize replaces fodder cereals area, resulting in a decreased production of fattening bulls. In the scenario EmaizeWW the decrease of TGM is smaller than in EmaizeSM because more grassland is converted into arable land, providing more resources for cash crop production.

Cereals production decreases in both scenarios in AL-CC and AL-FC farm types because energy maize production replaces cereals production. The larger area of energy maize in the scenario EmaizeWW results from larger replaced cereals area (e.g. in GL-IG) and larger areas converted from grassland to arable land (e.g. in GL-FC). The reduction of cereals used as fodder and the reduction of fodder crops area result in all farm types in a slight reduction of fattening bulls.

Since in both scenarios all farm types replace intensive crop wheat by intensive crop energy maize, the change of intensive crop intensity is small in arable farm types. In grassland farm types the increase of intensive crop area results from converted grassland and an increase in arable area. Intensive variant area is increased in both scenarios in AL-FC, GL-IG and GL-EG farm types.

In both scenarios nitrogen intensity tend to decrease. The weighted index shows slight increases due to decreased intercrop area in AL-FC and GL-EG. Extreme changes are observed for the erosion potential, which is for maize defined as quite large.

In EmaizSM farm types GL-IG show a decrease of erosion potential. GL-IG consider only three NUTS3 counties EM, FR, LOE out of which EM and FR show small changes of erosion potential, while LOE shows an extremely decreasing development of indicator value (cf. Section 3.3.4).

The change in GHG emissions is not significant for the complete model region but shows decreasing tendencies for AL-CC and AL-FC and increasing tendencies in GL-FC and GL-EG due to converted grassland. AEM area decreases due to reduction in grassland and in intercrops area.

Table 3.3-6: Development of indicator values in EmaizSM and EmaizeWW.

		EmaizeSM						EmaizeWW					
		AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	All[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	All[g]
SUB[m] volume	[pp]	1	-2	2	-1	-1	0	-1	-2	1	-2	-1	-1
SUB volume Pillar 1	[pp]	3	2	0	2	2	2	4	3	2	3	2	3
SUB volume Pillar 2	[pp]	-10	-12	3	-4	-5	-5	-20	-17	0	-7	-6	-9
TGM[n] volume incl. SUB	[pp]	-3	-2	0	-1	1	-3	-4	-1	-1	0	-1	-2
TGM volume excl. SUB	[pp]	-4	-2	0	-1	1	-3	-5	-1	-1	0	0	-2
Cereals	[pp][o]	-6	-4	-2	-2	-1	-3	-19	-14	-2	-6	-5	-11
Maize	[pp][o]	7	5	4	4	1	5	21	17	3	11	9	14
Grain maize	[pp][o]	0	0	-1	0	0	0	-2	0	-3	0	0	-1
Energy maize	[pp][o]	7	5	5	4	1	5	23	17	6	11	9	16
Fodder crops	[pp][o]	0	0	0	0	0	0	-1	-1	-1	0	-1	-1
Others[p]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Root crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Oil seeds and legumes	[pp][o]	0	0	0	0	0	0	-1	-1	0	0	0	-1
Set-aside area	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Conv. of grassland[q]	[pp][o]	0	1	2	2	0	1	0	0	0	4	1	1
Conv. of arable land[r]	[pp][o]	0	0	0	0	0	0	0	0	0	0	-1	0
Intensive grassland	[pp][o]	0	0	-2	0	0	0	1	0	0	-1	0	0
Extensive grassland	[pp][o]	-1	-1	0	-2	0	-1	-2	-1	-1	-3	-3	-2
Abandoned UAA[s]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Dairy cows	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Bulls	[%]	-1	-1	0	-1	-1	-1	-2	-1	-1	-1	-1	-2
Fattening pigs	[%]	-1	0	0	0	0	0	-1	0	0	0	0	0
Intensive crop area	[pp][o]	1	1	-2	3	4	1	3	2	1	5	3	3
Intensive variant area	[pp][o]	-2	4	6	-3	6	1	-2	6	6	0	6	2
Nitrogen total	[%]	-3	-3	-3	-3	1	-2	-3	-4	0	-1	2	-2
Nitrogen total (weight.)[t]	[%]	0	2	-4	-1	2	0	2	4	0	1	3	2
Nitrogen organic	[%]	-1	-1	0	-1	-1	-1	-1	-1	0	-2	-1	-1
Nitrogen demand	[%]	-3	-5	-5	-3	3	-2	-4	-6	0	2	5	-2
Erosion potential	[pp][u]	31	32	-11	33	40	30	50	48	7	56	43	46
Erosion potential (weight.)[t]	[pp][u]	35	36	-12	34	38	30	55	52	6	56	42	46
GHG[v] emissions	[%]	-1	-1	-1	1	1	0	-1	-1	0	2	2	0
Potential AEM area[w]	[pp][o]	-9	-3	-11	-7	-6	-4	-30	-14	-7	-11	-7	-17

Notes: a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percent share of UAA/percentage points of UAA compared to the share in reference situation. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare/difference in percent. u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. v: Potential in percent of uncovered arable land/difference in percent. w: Green house gas. x: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity.

3.3.6 Analysis of results according to achievement of policy objectives

With respect to the economic policy objectives both scenarios are neutral. Neither subsidy volume nor TGM is changed significantly.

The supply of food production is influenced negatively in both scenarios particularly in arable farm types. In the scenario EmaizeWW the impact is stronger and also cereals production of farm types GL-FC and GL-EG is impacted negatively. Supply of energy production is impacted positively (increase of energy maize area), the impacts are more extreme in EmaizeWW than in EmaizeSM. The negative impact on animal production appears in nearly all farm types and in both scenarios (cf. Table 3.3-7). However, the negative impact on pig and bulls production is smaller than the benchmark defined in this study for a significant negative impact (cf. Section 2.1) and thus it is not indicated in this analysis

Negative impacts on environmental objectives are found especially with respect to the erosion potential. Only in EmaizeSM the farm type GL-IG is impaced positively with regard to erosion potential. The impact of AEM area is in most of the farm types negative and in some neutral. Table 3.3-8 presents the developments of indicator values and impact on the policy objectives as defined in this study (cf. Section 2.1).

Table 3.3-7: Impact on policy objectives in EmaizSM and EmaizeWW.

		EmaizeSM						EmaizeWW					
		AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	All[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	All[g]
SUB[m] volume	[pp]	0	0	0	0	0	0	0	0	0	0	0	0
SUB volume Pillar 1	[pp]	0	0	0	0	0	0	0	0	0	0	0	0
SUB volume Pillar 2	[pp]	++	++	0	0	+	+	++	++	0	+	+	+
TGM[n] volume incl. SUB	[pp]	0	0	0	0	0	0	0	0	0	0	0	0
TGM volume excl. SUB	[pp]	0	0	0	0	0	0	-	0	0	0	0	0
Cereals	[pp][o]	- -	- -	0	0	0	-	- -	- -	-	-	-	- -
Maize	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Energy maize	[pp][o]	+	+	+	0	0	+	++	++	+	++	+	++
Fodder crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Others[p]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Root crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Oil seeds and legumes	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Set-aside area	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Conv. of grassland[q]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Conv. of arable land[r]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Intensive grassland	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Extensive grassland	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Abandoned UAA[s]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Dairy cows	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Bulls	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Fattening pigs	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Intensive crop area	[pp][o]	0	0	0	0	0	0	0	0	0	-	0	0
Intensive variant area	[pp][o]	0	0	-	0	-	0	0	-	-	0	-	0
Nitrogen total	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen total (weight.)[t]	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen organic	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen demand	[%]	0	+	+	0	0	0	0	+	0	0	-	0
Erosion potential	[pp][u]	- -	- -	- -	- -	- -	- -	- -	- -	-	- -	- -	- -
Erosion potential (weight.)[t]	[pp][u]	- - -	- - -	+ +	- - -	- - -	- - -	- - -	- - -	-	- - -	- - -	- - -
GHG[v] emissions	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Potential AEM area[w]	[pp][o]	- -	- -	0	-	0	- -	- -	- -	0	- -	-	- -

a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percentage points of utilized agricultural area compared to the share in reference situation. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. u: Percentage points difference from reference situation. v: Green house gas. w: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity.
+ small positive impact on objective, ++ medium positive impact on objective, +++ highest positive impact on objective
- small negative impact on objective, - - medium positive impact on objective, - - - highest positive impact on objective, 0: no impact on objective

3.3.7 Scenario discussion

This subsection discusses the modelling approach for energy crop production simulation and compares the impacts on the policy objectives which have been analyzed. Furthermore the scenario results of this study are compared with results of other policy impact studies.

Modelling approach to simulate energy crop scenarios

Due to a lack of historical data for energy crop production, the historical data in this study are derived from crops which reflect the competitiveness of energy maize production. The calibration parameter of silage maize and winter wheat are used to simulate scenarios of weak competition and strong competition between energy maize production and food production. This modelling technique of using different calibration parameters for the same activity follows an approach of Gömann et al. (2007), however it differs from the techniques used in other simulation scenarios in the study at hand, where exogenous parameters are changed, like e.g. changing the payments (cf. Section 3.2) or model constraints area used (e.g. to simulate production quota and demand restrictions, cf. Section 3.1). The change of calibration parameters results in a change of the activity specific competition in comparison to other activities.

It is not known how the producers would evaluate economically the cropping activity of energy maize (more comparable to winter wheat or more comparable to silage maize), and how the economic competition of the energy crop production activity would be. So it seems to be plausible to simulate these scenarios by different activities and keeping exogenous parameters (as prices, costs, and yields) ceteris paribus, instead of changing them exogenously.

In order to evaluate the results of energy maize extension in the scenarios, the simulated energy maize area is compared with the latest available statistical data of acreage of energy crops published in MLR (2008). Table 3.3-8 presents the statistical data in the year 2007 and compares it with data calculated for the year 2015. The acreage in the scenario EmaizeWW is projected to be about ten times higher than in the historical data of 2007. Thus, the competiveness of energy maize production in comparison to food production is simulated in the scenario EmaizeWW to be significantly higher than it can be observed by the historical data for the year 2007. The results for energy maize area in EmaizeSM are in a similar range as the historical data of 2007, and have been considered as useful to calculate the WAD (cf. Section 2.3) only for the scenario EmaizeSM. Due to obvious extreme deviations the calculation of a WAD for the EmaizeWW scenario has not been executed. The regional acreages are met quite precisely in most of the NUTS3 countries, with a WAD of 0 to 2. Thus, the results indicate that if energy maize production is considered as being nearly as competitive (as it is assumed in scenario EmaizeSM) the simulated production of energy maize is comparable with the historical production data of the year 2007.

Table 3.3-8: Regional data and forecasting error of energy crop production.

	Statistic acreage	ACRE Simulation	Deviation EmaizeSM and Statistics			ACRE Simulation
	MRL 2008B	EmaizeSM	Deviation	Forcasting error	Weighted forecasting error	EmaizeWW
	pp of UAA	[%]	pp	%	%	pp of UAA
SKR STUTTGART	3	4	1	33	1	32
BOEBLINGEN	4	5	1	25	1	35
ESSLINGEN	3	5	2	67	2	28
GOEPPINGEN	2	0	-2	100	2	16
LUDWIGSBURG	7	9	2	29	2	37
REMS-MURR-KREIS	2	0	-2	100	2	15
SKR HEILBRONN[d]			0	--	--	
HEILBRONN	2	6	4	200	4	37
HOHENLOHEKREIS	3	7	4	133	4	35
SCHWAEBISCH HALL	2	3	1	50	1	16
MAIN-TAUBER-KREIS	4	7	3	75	3	39
HEIDENHEIM	5	5	0	0	0	30
OSTALBKREIS	2	5	3	150	3	18
SKR BADEN-BADEN[a]	0		0	--	--	
SKR KARLSRUHE[e]	0		0	--	--	
KARLSRUHE	4	6	2	50	2	40
RASTATT	6	2	-4	67	4	12
SKR HEIDELBERG[c]	0	0	0			42
SKR MANNHEIM[c]	0		0			
NECKAR-ODENWALD-KR	4	8	4	100	4	33
RHEIN-NECKAR-KREIS	5	9	4	80	4	44
SKR PFORZHEIM[f]	13		-13	100	13	
CALW	2	2	0	0	0	17
ENZKREIS	4	12	8	200	8	38
FREUDENSTADT	0	1	1	--	--	18
SK FREIBURG IM BREISGAU[b]	0		0	--	--	--
BREISGAU-HOCHSCHWARZWALD	1	1	0	0	0	7
EMMENDINGEN	3	5	2	67	2	14
ORTENAUKREIS	2	6	4	200	4	0
ROTTWEIL	10	1	-9	90	9	18
SCHWARZW.-BAAR-KR.	7	0	-7	100	7	4
TUTTLINGEN	4	0	-4	100	4	5
KONSTANZ	11	8	-3	27	3	25
LÖRRACH	1	6	5	500	5	16
WALDHUT	5	4	-1	20	1	7
REUTLINGEN	5	0	-5	100	5	7

	Statistic acreage	ACRE Simulation	Deviation EmaizeSM and Statistics			ACRE Simulation
	MRL 2008B	EmaizeSM	Deviation	Forcasting error	Weighted forecasting error	EmaizeWW
	pp of UAA	[%]	pp	%	%	pp of UAA
TUEBINGEN	4	6	2	50	2	34
ZOLLERNALBKREIS	3	1	-2	67	2	13
SKR ULM[g]	0		0	--	--	--
ALB-DONAU-KREIS	23	4	-19	83	19	35
BIBERACH	15	13	-2	13	2	29
BODENSEEKREIS	1	6	5	500	5	14
RAVENSBURG	3	4	1	33	1	8
SIGMARINGEN	8	4	-4	50	4	0
Baden-Wuerttemberg	5	5	0	0	0	21

a) to g) aggregate to… a) …Rastatt, b) …Breisgau-Hochschwarzwald, c) …Rhein-Neckar-Kreis, d) …Heilbronn, e) …Karlsruhe, f) …Enzkreis, g) … Alb-Donau-Kreis. h) Source: own calculation based on MRL 2008B. Bodennutzung in Baden-Wuerttemberg zunehmend im Zeichen erneuerbarer Energien, i) bioenergy here specific: biogas

Source: MRL 2008B

Discussion of the results according to achievement of policy objectives

The discussion of pros and cons of bioenergy production is ambiguous with respect to positive and negative impacts on different policy objectives, as for example published in the studies BMVEL (2007) and SABAP (2007). The results of both studies are compared and discussed with the impacts analysed for the simulated scenarios in this study at hand.

The increase of production of renewable resource crops is a declared target of the national German as well as the regional government of Baden-Wuerttemberg (cf. Subsection 3.3.1). Both governments do not have concerns about the benefits of an increased energy crop production, and they suppose that problems can be avoided by adapted measures (e.g. land and crop management, innovations, and research) (BMVEL 2008A, MLR 2006A).The study SABAP (2007) analysed the arguments for energy crop production and highlights also risks and negative impacts of bioenergy production. They conclude that a fundamental revision of German bioenergy policy is necessary with focus on the most efficient forms of renewable crop production and with monitoring of the expected risks and negative impacts (SABAP 2007). Table 3.3-10 compares the positions of the SABAP (2007) and BMVEL (2008A) and the results of the two energy crop scenarios calculated in the study at hand.

Competitive objectives: energy supply vs. food supply

The BMVEL (2008A) regards the competition between food crops and energy crops as known phenomenon, implying rather positive effects than harming food security. Land scarcity resulting from the competition between food and bioenergy production can result in an increase of prices for agricultural products. This would mean an increase of incentives for production of food and bioenergy and therefore agricultural production would increase, which would avoid harming food supply.

However, in Germany, there are supposed to be enough land resources for agricultural production and food security would not be in danger (BMVEL 2008A). Furthermore some studies assume that in the future less UAA will be under agricultural production and thus this land will be set free for energy crop production (SABAP 2008: 212). The potential area for energy production for the year 2020 is estimated to be between 15 to 29% of UAA in Germany (BMVEL 2008A) and between 10 to 15% of UAA in Baden-Wuerttemberg (MLR 2006A).

Most of the impact studies which argue with sufficient availability of production area in Germany assume that the current status of national self-sufficiency in food supply holds also for the future. However, several aspects of potential future development in food supply should be considered. The German agricultural sector supplies also the world market with food exports. The world wide food demand is supposed to further increase, and this might result in an increase of food prices and also an increase of food production in Germany. Such a development could provoke that - in contrary to the assumptions of the studies mentioned above - areas set free by decreases in fodder crop and set-aside area might not be used for energy crop production but for food production instead. Thus the expansion of energy crop production would be more limited than under the assumption of the current food supply situation.

The competition between energy crops and food production is also strongly impacted by the development of fossil fuel prices. On the one hand, an increase in crude oil price results in increased prices for input factors (e.g. mineral fertilizer) and thus in increased production costs for agricultural products. On the other had an increased fossil fuel price increases the competitiveness of biofuels on the energy market. When drawing conclusions from the price interdependencies both of these aspects have to be considered (SABAP 2008).

The results of the study at hand indicate the competition between food and energy maize production. In both energy crop scenarios the scarcity of arable land results in the replacement of large areas of cereals. Also fodder crop area and bulls production are influenced negatively. The concerns about risks for food security could be justified when looking at the scenario results for Baden-Wuerttemberg. The replacement of cereals by energy maize is regionally focussed, and takes particularly place in the NUTS3 counties in the northern part of the model region which are of high importance for cereals production in Baden-Wuerttemberg. This indicates that a monitoring would be necessary to avoid the risks for decreased cereals supply in Baden-Wuerttemberg.

Environmental objectives

Increased energy maize production will result in expansion of maize area. In a future scenario with large extent of energy maize production mono cropping of energy maize might dominate the agricultural landscape and result in a loss in agri-biodiversity. However, this problem can be tackled and solved by crop management, with the introduction of an energy crop mix and innovations in breeding (BMELV 2008A).

The results of the scenario EmaizeWW show that in some counties the area of energy maize is extended largely up to 30 to 40% of UAA. In these counties cereals area might be replaced and would imply a change towards a mono cropping maize landscape. In some single counties additional arable land of 10 to 14% of UAA is provided by conversion activities indicating that the landscape of these counties might be influenced by the higher share of arable land. However, the larger part of conversion activities result from the reduced conversion of grassland into arable land in the CAP2003 (baseline) scenario. Thus, in comparison to the reference year the share of arable land is not increased, just the extensification effects resulting from CAP2003 scenario are partially compensated (cf. Section 3.1). Thus, in comparison to the reference year with more arable land, landscape might not be changed that significantly with respect to arable land and grassland share. In the EmaizeWW scenario soil erosion increased significantly in all counties, due to the high soil intensity of energy maize. Thus, with respect to regionally extreme changes of energy maize production, environmental programs or standard management requirements (SMR) should be applied to avoid more negative environmental impacts, such as soil erosion.

With respect to climate protection the benefits of energy crop production is still a controversial discussion. However, the European Commission considers that GHG emissions, including CO_2, from renewable energy sources are either low or zero and an increase of the share of renewables in the EU fuel mix would result in significantly lower GHG emissions (EC 2006A: 14). Thus, according to the European Commission energy maize production would be considered as an activity that decreases GHG emissions. The impact of nitrogen fertilization and N_2O emission on climate change are an ongoing topic of research. Increased application of mineral nitrogen increases N_2O emission, however, this is not only limited to energy crop production. Thus, the net benefits of energy crop production, i.e. emission of N_2O versus avoiding CO_2 emissions, need to be further investigated (cf. BMVEL 2008A). The SABAP (2007) for example points out that the increased production of energy crops could result in increased GHG emissions. Their argumentation comprises also N_2O emissions from soil activity. SABAP (2007) argues that a scarcity of arable land and high agricultural prices will result in a conversion of grassland into arable land, i.e. additional N_2O would be emitted due to soil activities. In addition, a replacement of food crops in Germany under a high global food demand might result in an increase of food production in other areas of the world and there soil not used currently could be converted into arable land and this would also increase global N_2O emissions due to soil activity (SABAP 2007).

The results presented in the energy crop scenarios do not directly confirm increasing GHG emissions. ACRE calculates GHG emission resulting from fertilization and animals stock, which counterbalance each other due to an increase of fertilization on the one hand and a decrease of livestock on the other hand. However, in ACRE the GHG emissions due to conversion of grassland into arable land are not considered in the calculation of the GHG emission indicator. Thus, when the slightly increased conversion activity of grassland in the energy crop scenarios is interpreted as a source for N_2O emission the scenario results are in line with the expectation of SABAP (2007) that the slightly increased energy production result in scarcity of arable land and provokes an increased activity of land conversion. However, the impacts of grassland conversion might be smaller than expected in this study, because in the energy crop scenarios most of the arable land used for energy crop production is rather retrieved from production area of other arable crops (e.g. cereals) than from converted grassland.

Economic objective employment

On the one hand the BMELV (2007A) and the MLR (2006A) expect that increased energy crop production creates new jobs in rural areas. On the other hand the SABAP (2007) estimates that expanded bioenergy generation results in balanced or only slightly positive or even negative affects of employment in arable regions due to its competition with animal production. The results of the energy crop scenarios underline this argumentation of stable to decreased employment. Map 3.3-7 a to d indicate a trend of decreased employment due to increased energy maize production and decreased livestock production in both scenarios, particularly in EmaizeWW. However, it has to be kept in mind that in ACRE only agricultural production is considered, and thus potential positive employment effects outside the agricultural sector that might arise due to energy production are not taken into account.

Table 3.3-9: Comparison of consequences of energy crop production according to BMELV (2008), SABAP (2007), and engery crop scenarios.

Objectives	BMELV 2008	SABAP 2007	EmaizeSM	SmaizeWW
	Statements		**Analysis of results**	
	increased production of renewable resource crops is a declared target	ask for a clear strategy and for concerning efficiency and net benefits		
Supply objective: competition for arable land, scarcity of land resources	no problem, enough UAA available, competition for UAA is a desired effect, as agricultural prices might increase	area potential is restricted because food production and energy crop production will compete	competition between cereals and energy crop production	competition between cereals, fodder and energy crop production
Environmental objectives: environmental pollution, GHG, emissions, landscape and biodiversity	increased fertilization with mineral fertilizer results in increased N_2O emissions	increased fertilization with mineral fertilizer and increased conversion into arable land emissions result in increased N_2O emissions	soil erosion is increased significantly	an increased share of arable land changes landscape slightly; soil erosion is increased significantly
Economic objective/rural area: employment	chance for creation of new jobs in rural areas	slight increase or decrease of employment	slightly decreased employment due to decreased animal production	slightly decreased employment due to increased energy maize production and decreased animal production

3.4 Nitrogen reduction scenarios

This chapter describes the simulation of a scenario which considers the objective of reducing nitrogen emissions from agricultural production. Nitrogen emissions result from mineral and organic fertilization in crop production as well as from pure manure decomposition from livestock production. Two nitrogen reduction scenarios have been analysed: one scenario with a reduction of organic nitrogen emission according to the national German regulation (the Düngeverordung (DüV)), and another scenario with a reduction of total nitrogen entrance by 10% derived from the OSPAR convention[46]. The scenario simulations have been done by using two different model constraints for input of organic nitrogen as well as for the input of total nitrogen.

The following subchapters describe the scenario background (Subsection 3.4.1), and the scenario assumptions (Subsection 3.4.2). The modelling of the scenario is delineated in Subsection 3.4.3. The Subsections 3.4.4 and 3.4.5 present the analysis of the results according to NUTS3 counties as well as according to farm types. A scenario discussion follows in Subsection 3.4.6.

3.4.1 Scenario background

Agriculture and the nitrogen cycle

Nitrogen is a common element in nature and an essential element for plant growth and development and also a key agricultural input. However, in excess it can lead to harmful environmental and human health effects. In agricultural production especially the negative environmental impacts of nitrogen leaching into ground water and nitrogen emissions into the atmosphere are subject to public concerns. Increased nitrate concentrations provoke decreased quality of drinking water and disturbance of aquatic ecosystems by eutrophication. Nitrogen emissions into the atmosphere increase the concentration of the N_2O, a greenhouse gas deemed to contribute to global warming and climate change (EC 2002A: 7).

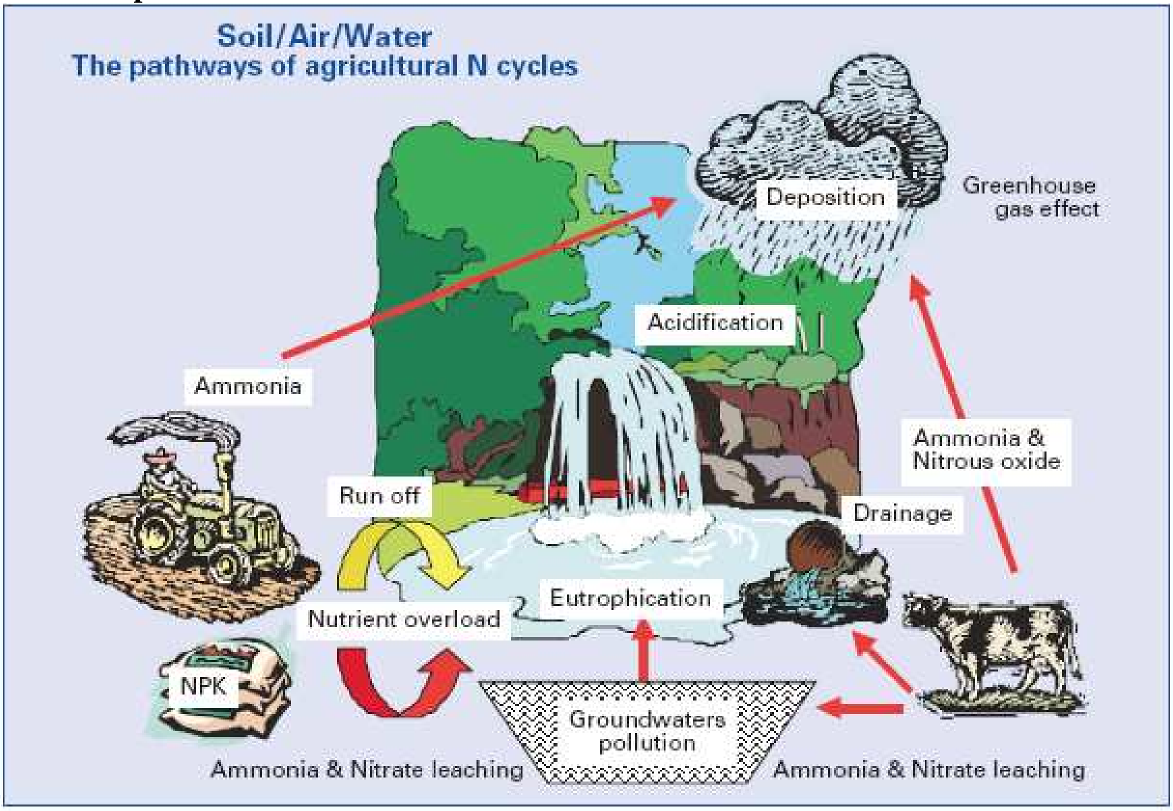
Nitrogen entrance by agricultural production results from fertilization with mineral and organic fertilizer. The objective of nitrogen fertilization is to maintain the soils' nitrogen balances. Crops extract nitrogen from soil for growing of biomass. Harvesting of the biomass extracts the nitrogen from the soil-crop system and transfer the nitrogen into the nutrition

[46] The Convention for the Protection of the marine Environment of the North-East Atlantic

chain of human, animals or into industrial use. To retain the soil productivity for crop production the nitrogen balance has to be equalized and therefore the nitrogen deficit resulting from removed biomass is compensated by nitrogen from mineral or organic fertilizer. Beside for retaining the soil productivity, fertilization is required to increase crop yields on soils with small productivity.

Another reason of nitrogen entrance into soil and water by agriculture is the decomposition of manure from livestock production. Manure can be used as organic fertilizer, however in regions with intensive livestock production the nitrogen from manure can exceed the required nitrogen for a balanced soil equilibrium (EC 2002A). Thus, the environmental pressure due to nitrogen leaching into ground and surface water as well as of N_2O emission into the atmosphere is particularly high in regions with intensive livestock production.

Figure 3.4-1: The exchanges of agricultural nitrogen with soil, air and water and possible impacts on the environment.



Source: EC 2002A: 10

Figure 3.4-1 illustrates the different pathways of the nitrogen cycle from agriculture (EC 2002A: 10). About 50 to 80% of the nitrogen input from agricultural production is lost and is not stored in soils to be available for crops. This nitrogen losses are recycled to water and soils and cause groundwater enrichment and eutrophication of surface waters. Combined with phosphorus they can cause "acid rains" and damage also terrestrial flora and soils. About 20 to 50% result in inert nitrogen gas (N_2) and in the GHG nitrous oxide (N_2O). This process is called denitrification and is done by soil and sediment bacteria. In certain types of soils and in groundwaters this process takes also place as a natural chemical reduction.

The mineral nitrogen fertilizer can directly bring ammonium and nitrates into groundwaters by leaching and run-off and subsoil "drainage" transports these substances into surface waters. The ground conditions and the time of application determine the extension of these effects. Organic N (in manure) is transported via the same "pathways" as mineral nitrogen. Additionally, the processes of volatilisation and incomplete denitrification result in ammonia (NH_3) and N_2O diffusion into the atmosphere. From the atmosphere nitrogen is transported to soil and waterbodies via wet deposition by rain or as dry atmospheric deposition directly. The nitrogen quantity from wet and dry depositions ranges from 10 to 30% of the initial N excreted by animals (EC 2002A: 10).

Status quo of nitrogen pollution in the EU, Germany and in the model region

During most of the last sixty years greater intensification, increasing crop areas and higher productivity of crop production resulted in an increase of nitrogen fertilization. On the other hand the introduction of milk quotas and of premiums for suckler cows and ewes in 1984 and 1992 reduced and stabilized numbers of cattle and sheep. However livestock numbers in the pigs and poultry sector expanded and the production intensity of pigs, poultry and bulls increased on individual farms (EC 2002A: 8). This intensification resulted in an increasing intensity of manure decomposition.

Table 3.4-1: Oversupply of nitrogen in the German federal states.

	1990	1995	2000	2005
	kg N ha^{-1}			
Baden-Wuerttemberg	116	98	95	76
Bavaria	129	108	108	83
Hessen	99	79	79	61
Lower Saxony	124	106	108	85
Nordrhine-Westphalia	131	111	112	91
Rhineland-Palatinate	86	73	72	55
Saarland	100	85	83	65
Schleswig-Holstein	125	107	106	86
Brandenburg	n.d.	66	67	53
Mecklenburg-Vorpommern	n.d.	56	56	38
Saxony	n.d.	77	75	53
Saxony-Anhalt	n.d.	56	57	41
Thuringia	n.d.	70	69	51

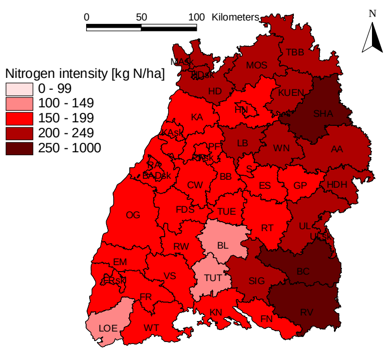
Source: BMU-BMVEL. Notes: n.d.: no data

Table 3.4-1 shows the nitrogen oversupply in the federal states of Germany. In the years 2000 and 2005, the study region Baden-Wuerttemberg was with an oversupply of 95 kg/ha and 76 kg/ha nitrogen from agricultural production with Bayern, Niedersachsen, North-Rhine Westfalia and Schleswig-Holstein among the top five federal states with an oversupply of nitrogen in agricultural production.

Maps 3.4-1 a and b present the intensity of input of nitrogen calculated for the reference year (REF) and in the year 2015 in the baseline scenario CAP2003. Figure 3.4-2 a and b present the concentrations of nitrogen in the groundwater as measured by the "groundwater monitoring program" in the years 2000 and 2007 (LfU 2001). The comparison of the maps shows that the simulation of nitrogen input reflects to a great extend the regional distribution of nitrate intensity measured. Regions with high nitrogen input and nitrate concentration are similar in all maps, illustrating the situation in the years 2000, 2007 and 2015, like e.g. Unterland and the South East. Regions with less nitrogen and nitrate entrance are the extensive counties of Schwäbische Alp and Schwarzwald. Figure 3.4-2 c shows the regions which are critical with respect to groundwater nitrate concentration and thus demand for measurements for reduction of nitrate input. These 'hot spots' are found in Unterland, in upper Rhein area and the county RV.[47]

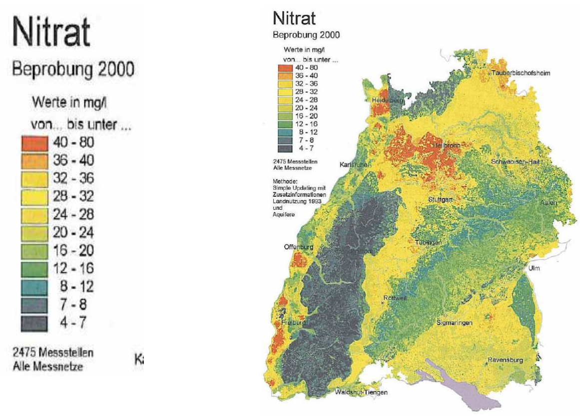
Figure 3.4-2: Regional nitrogen and nitrate intensity measured or simulated in the years 2000, 2007 and 2015.

Map 3.4-1 a: Nitrogen intensity in ACRE simulation REF 2000.



Notes: Unit: kg N ha^{-1}

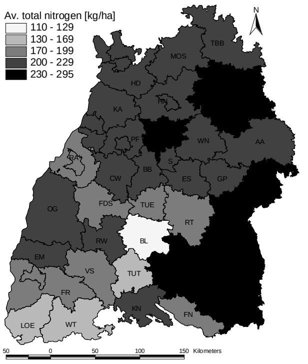
Figure 3.4-2 a: Nitrate intensity in ground water in measures of 2000.



Source: LfU (2000): Grundwasserüberwachungsprogramm 2000: Ergebnisse der Beprobung 2000.

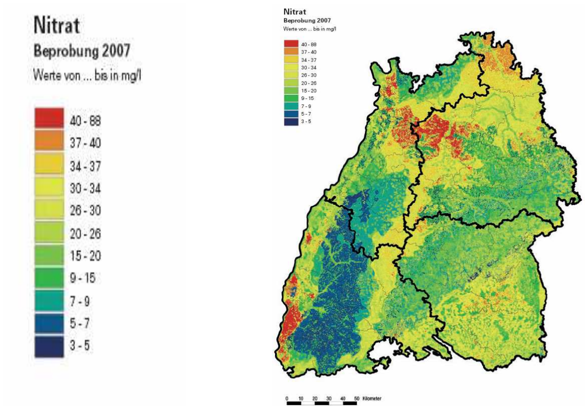
[47] For a larger presentation of the maps see Appendix 3.

Map 3.4-1 b3: Nitrogen intensity in ACRE simulation CAP 2015.



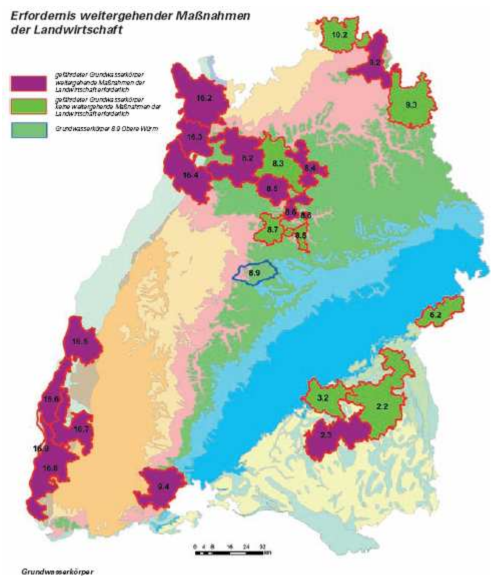
Notes: Unit: kg N ha^{-1}

Figure 3.4-2 b: Nitrate intensity in measures of 2007.



Source: LfU-BW (2008): Grundwasserüberwachungsprogramm 2007: Ergebnisse der Beprobung 2007.

Figure 3.4-2 c: Problematic zones with need of measures to reduce nitrogen input.



Notes: The dark zones indicate the problematic zones with need of measures to reduce the nitrogen input. Source: LfU-BW 2008.

3.4.2 Scenario assumptions

Due to "growing public concerns about steadily increasing nitrate concentrations in drinking water resources, and disturbance of aquatic ecosystems by eutrophication" the EU released regulations in order to improve water quality by reducing emissions of hazardous substances (EC 2002A: 7). Among these regulations are the EU Water Framework Directive (WFD) and the OSPAR Convention, which are both used in this study as a benchmark for the nitrogen reduction scenarios.

EU Water Framework Directive (WFD)

In 2000 the European Parliament and the European Council published the EU Water Framework Directive (WFD)[48]. The WFD was implemented in order to achieve a progressive reduction of emissions of hazardous substances into water and to contribute to a good water quality for all waters across the European Union by 2015 (EU 2003A). The WFD implies (1) the mandatory consideration of other directives (e.g. for reduction and prevention of pollution) and (2) measures which are supplementary measures (e.g. for controlling or monitoring issues).

Directives: Nitrates Directive and Plant Protection Products Directive

The WFD comprises seven old single directives among which the Nitrates Directive is one. The Nitrates Directive requires that in agricultural production fertilization is done according to the code of good agricultural practice (EC 2002A: 43), which is defined in Germany by the Düngeverordnung (DüV). According to the DüV the application of manure is allowed for up to 170 kg N ha^{-1} from manure applied on average of the individual farm (DüV 2007: §4 (3)). A so-called "special approval" exists for intensively used grassland, where the upper limit for nitrogen input from manure is 230 kg N^{-1}. This option of the special approval is currently under review of the European Commission (MRL 2006B, Merkblatt Änderungen DüV). In case of a rejection of the special approval German farmers have to limit the manure N input to 170 kg ha^{-1} and intensive farms currently using this special approval might be affected significantly. Under the special approval, which has to be applied for annually, farmers have to comply with certain statutory management requirements (SMR). For instance the intensively managed grassland areas for which the approval applies for have to be cut at least four times per year and the nitrogen balance has to be equalized over a time period of three years (DüV 2007: §4 (4)).

Supplementary measures

The supplementary measures complement the directives and are regionally applied measures and instruments. They can include legislative instruments, research, development and demonstration projects (e.g. "Nitratinformationsdienst"), economic or fiscal instruments and

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[48] Full title "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy"

codes of good practice (e.g. represented by cross-compliance). In the study region Baden-Wuerttemberg the legislative instrument is the Schutzgebiets- und Ausgleichs-Verordnung für Wasserschutzgebiete (SchalVO), while a supportive service is provided by the "Nitratinformationsdienst". Both measures are anchored in the Pillar 2 by the agro-environmental program MEKA3. SchALVO is a regional directive which aims at groundwater protection in declared or preliminary declared water protection areas. The targets of the directive SchALVO are avoiding and minimizing entrance of specific substances into groundwater as well as the restoration of groundwater resources (Sanierung von Grundwasservorkommen) by statutory management requirements (SMR) for groundwater protection. The compliance with groundwater protecting SMR can result in income losses for farmers. Therefore, the government of Baden-Wuerttemberg pays farmers a monetary compensation (e.g. a flat-rate compensation of 165 EUR ha^{-1} for UAA in groundwater protection zones) (MRL 2005B). The "Nitratinformationsdienst" is a service which provides information on nitrate concentration in soils. Data are surveyed from soil samples from UAA of participating farmers and the farmers receive fertilization recommendation for their soil and the gathered data are processed to regional nitrate concentration maps (Schweiger and Grimm 2004).

OSPAR Convention

The OSPAR convention (Convention for the Protection of the marine Environment of the North-East Atlantic) is an initiative for nitrogen reduction, and is not directly connected to agricultural production. The OSPAR convention aims at the reduction of pollution of the Marine Environment of the North-East Atlantic. Thus, this convention includes the countries bordering the Baltic Sea, the North Sea and the North East Atlantic. Water polluted in Baden-Wuerttemberg by industry and agriculture is transported via the rivers Neckar and Rhine into the North Sea. In the OSPAR convention the countries, bordering Baltic Sea, North Sea and the North East Atlantic, agree for adopting programmes and measures and harmonise their policies and strategies to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected (OSPAR Commission 2004). One specific target of the OSPAR convention is the reduction of nitrogen entrance by at least 10% related to the status quo of the period from 1990 to 1995 (OSPAR Commission 2004: 2).

3.4.3 Scenario modelling

Two Nitrogen reduction scenarios have been derived: one scenario based on the WFD, with an upper limit of manure allowed of 170 kg N^{-1} (Nred170kg) and another scenario based on OSPAR, with a reduction of total nitrogen input by 10% (Nred10%).

Nitrogen reduction scenario according to WFD: Nred170kg

Following the WFD the scenario DüV has been implemented under the assumption that the special approval for an exceptional upper limit of 230 kg N^{-1} has been rejected and the upper limit of manure allowed is 170 kg N^{-1}.The scenario is called Nred170kg (Nitrogen reduction scenario with maximal 170kg organic nitrogen) and the model constraint is defined according to the following equation, to which a constraint aims at the control of organic nitrogen intensity.

$$Norgint_{Nred170kg} = \frac{L_{ANIM} * Norgprod_{ANIM}}{UAA_{Norg}} \leq 170 \qquad \textit{Eq 3.4.1}$$

with
$Norgint_{Nred170kg}$: intensity of organic nitrogen in the scenario Nred170%
ANIM: Animal
L_{ANIM}: Livestock activity of animals
$Norgprod_{ANIM}$: animal specific nitrogen production
UAA_{Norg}: Utilized agricultural area with applied fertilization of organic nitrogen

Nitrogen reduction scenario according to OSPAR convention: Nred10%

Following the OSPAR convention the scenario Nred10% has been implemented to reduce the total nitrogen input to 90% of the amount in the reference year 2000. It has to be kept in mind that according to the OSPAR convention the nitrogen reduction is related to the period 1990 to 1995. However, the nitrogen entrance in the years 1990 to 1995 is bigger than in the year 2000 (cf. Table 3.4-1). Therefore a nitrogen reduction by 10% with regard to the year 2000 (and thus the reduction resulting from the simulated scenario Nred10%) might be higher than it would be if the reference years 1990 to 1995 would have been taken.

The reference amount of nitrogen in the model constraint is the sum of mineral nitrogen and organic nitrogen from livestock. The model constraint does not consider that organic nitrogen substitutes mineral nitrogen in fertilization or the absorption of nitrogen by crops. Thus the model constraint does not consider the nitrogen balance which would result in lower reference values. In consequence the aggregated nitrogen amount from mineral fertilizer and from manure is the reference value for the model constraint, which is formulated as follows:

$$Ntot_{Nred10\%} = \sum_{ANIM} L_{ANIM} * Norgprod_{ANIM} + Ndem_i * crop_i \leq 90\% * Ntot_{REF}$$

(Eq. 3.4.2)

with
$Ntot_{Nred10\%+}$: Total nitrogen amount in the scenario Nred10%
ANIM: animal
L_{ANIM}: livestock activity of animal ANIM
$Ndem_i$: specific nitrogen demand of crop i
$crop_i$: acreage of crop production activity of crop i
$Ntot_{REF}$: Total nitrogen amount in the reference year

3.4.4 Analysis of indicator values according to NUTS3 counties

This section describes the status and developments of the economic, supply and environmental indicator values. The analysis is done at regional level for the NUTS3 counties where agricultural production is represented by regional farms for the scenario Nred170kg with a restriction of organic nitrogen input to 170 kg ha^{-1} and the scenario Nred90% with a reduction of total nitrogen input by 10%.

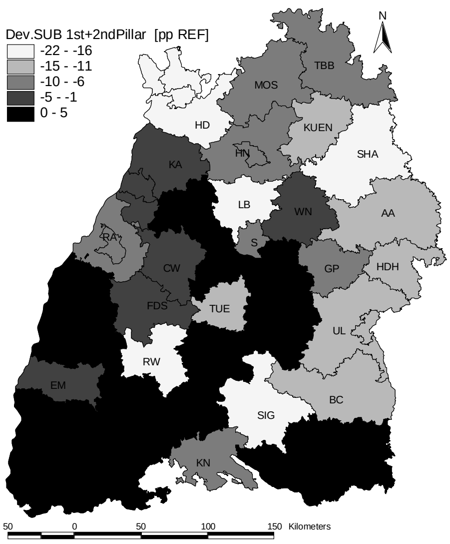
The scenario Nred170kg does not result in any changes of indicator values because the restriction given by the maximum of 170 kg organic nitrogen per hectare does not affect the agricultural production in the NUTS3 counties. The decrease of livestock due to the changes in the baseline scenario (CAP2003 scenario) already showed a reduction of the entrance of organic nitrogen at a level of between 20 to 150 kg ha^{-1} compared to the reference year situation (cf. Section 3.1). However, even in the reference year the limit of 170 kg ha^{-1} is not exceeded, because the level of organic nitrogen ranges from 30 kg ha^{-1} to 150 kg ha^{-1}. Thus, and even though the constraint for organic nitrogen might be binding at farm level for farms with intensive animal production (e.g. in SHA), the constraint modelled in the scenario Nred170kg is not binding at regional NUTS3 level. However, the constraint avoids an extension of animal stock which would exceed the constraint of 170 kg N ha^{-1}. Since an increase of animal stock cannot be observed in the results of scenario Nred170kg, only the results of the scenario Nred10% are analysed in the following paragraphs.

Development of economic indicator values

Maps 3.4-2 a and b show the changes in subsidies and the regional distribution of average subsidies in the NUTS3 counties in the Nred10% scenario. The reduction of total nitrogen input by 10% compared to the reference level results in a significant decrease of subsidy volumes in many counties, particularly in the intensive northern arable counties and the western fodder crop counties. Here abandoning of UAA results in a reduction of payments from Pillar 1 and Pillar 2. In addition to land abandoning the counties reduce the intensity by changes in crop production and by reduction of livestock.

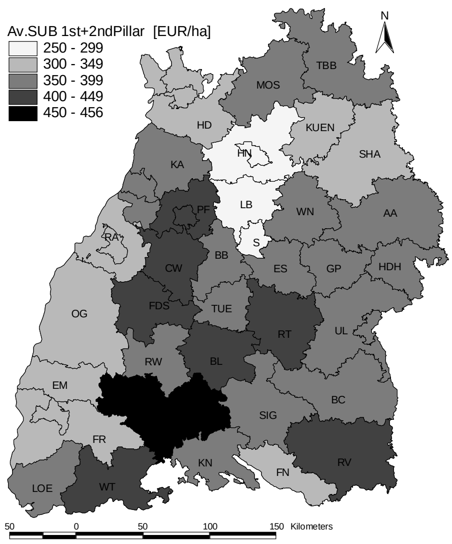
In the Nred10% scenario the reduction of production results in a decrease of total gross margin between -1pp to -13pp in the counties (cf. Map 3.4-2 c). The losses in TGM are highest in fodder crop counties where high animal density of bulls and pigs is reduced (e.g. in county SHA) or in cash crop counties where high shares of UAA falls abandoned (e.g. in county KA). A further reason for extreme decreases of total gross margin is the different sensitivity of percentage changes for different levels of basic values. Counties with small average total gross margin tend to show a more sensitive decrease (e.g. the extensive grassland counties RW, TUE) than counties with relatively high average total gross margin (e.g. HN). The distribution of average total gross margin differs in few counties (cf. Map 3.4-2 d) and the counties KA, PF and HDH show the smallest average TGM in the Nred10% scenario. In the subsidy reduction scenarios in this study the acceptable benchmark for TGM level in Baden-Wuerttemberg is defined as TGM level of the reference year (REF) (cf. Section 3.2). In Nred10% in the majority of NUTS3 counties the average TGM is still higher (ranging from 715 EUR ha^{-1} to 3172 EUR ha^{-1}) than in the reference year (reaching from 790 EUR ha^{-1} to 2900 EUR ha^{-1}), thus, the range of the income losses compared to CAP2003 of maximum 13pp can be regarded as acceptable.

Map 3.4-2 a: Change of SUB Pillar 1 and Pillar 2 in Nred10% compared to CAP2003.



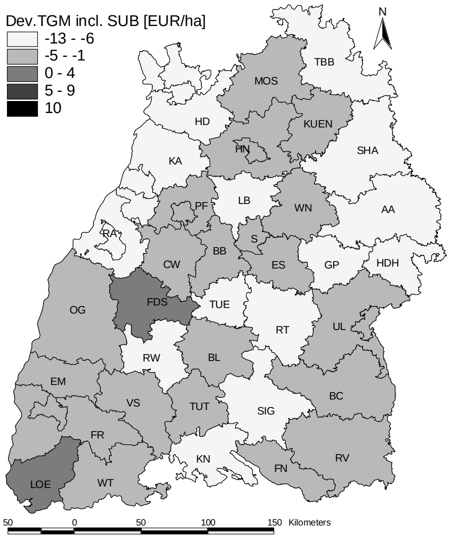
Notes: Unit: %, basis: REF.

Map 3.4-2 b: Average Pillar 1 and Pillar 2 in Nred90%.



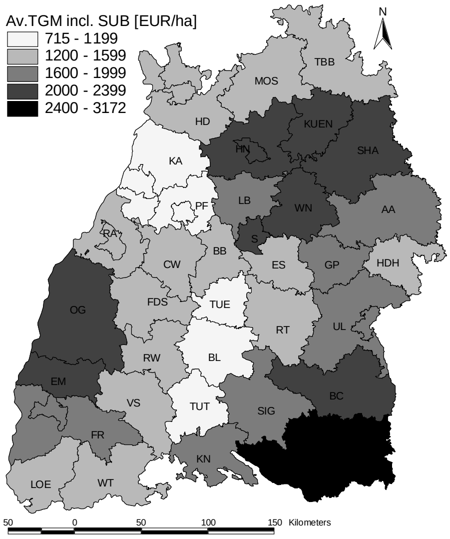
Notes: Unit: EUR ha^{-1}.

Map 3.4-2 c: Change of TGM incl. SUB in Nred10% compared to CAP2003.



Notes: Unit: %, basis: REF.

Map 3.4-2 d: Average TGM incl. SUB in Nred10%.



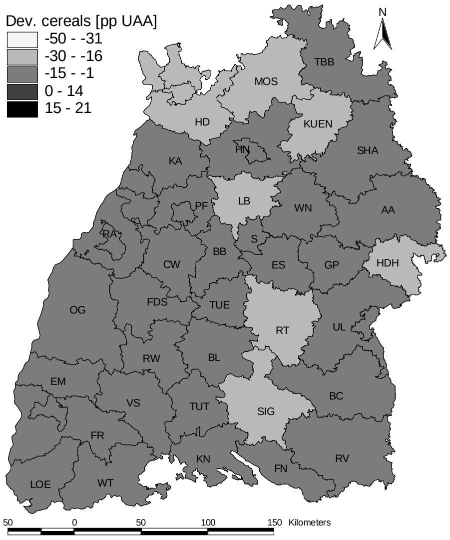
Notes: Unit: %, basis: REF.

Development of supply indicator values

Crop production

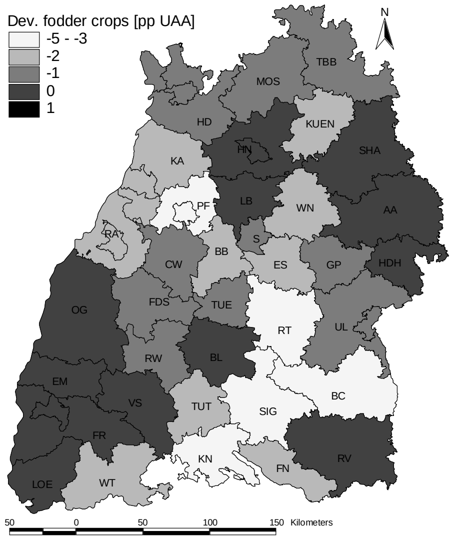
In Nred10% cereals area is reduced in nearly all counties by up to 30pp in order to reduce the demanded nitrogen amount (cf. Map 3.4-3 a). Fodder crop area tends to decrease in most of the counties due to reduced fodder demand (cf. Map 3.4-3 b). This happens particularly in fodder crop counties with large shares of fodder crop area, and reductions of fattening bulls stock. In counties where feeding of cattle is based on fodder cereals and on fodder crops the fodder crop area is kept constant to retain feeding of dairy cattle (cf. Map 3.4-3 d). The gross margin of dairy cattle activity is so high that it is not affected (e.g. SHA, AA).

Map 3.4-3 a: Change of cereals area in Nred10% compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

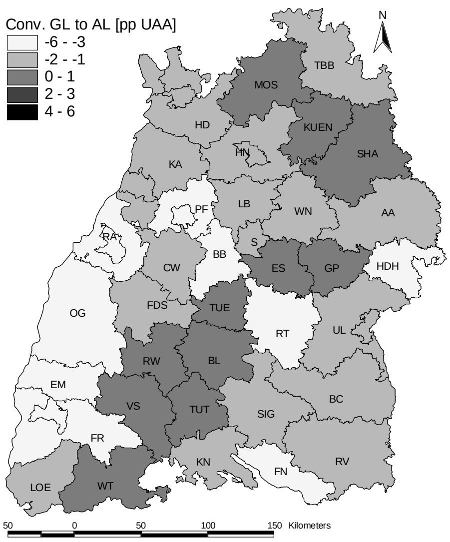
Map 3.4-3 b: Change of fodder crop area in Nred10% compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

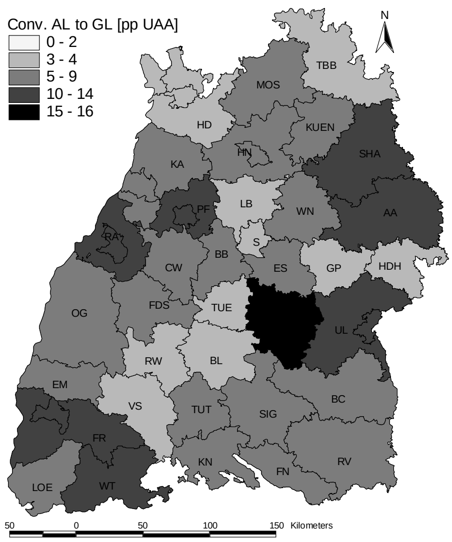
In Nred10% many counties do not tend to convert as much grassland into arable land than in the baseline scenario CAP2003 due to less fertilization of grassland and higher subsidies for grassland from Pillar 1 and 2. On the contrary several counties increase the conversion of arable land into grassland (e.g. FR, RT, SHA) (cf. Map 3.4-3 c, d).

Map 3.4-3 c: Change of converted grassland area Nred10% compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

Map 3.4-3 d: Change of converted arable area Nred10% compared to CAP2003.

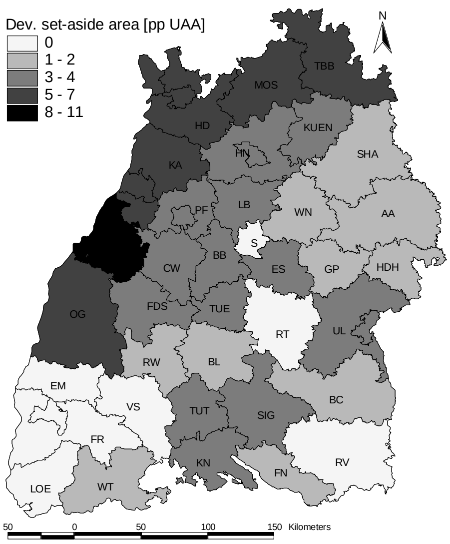


Notes: Unit: pp UAA, basis: REF.

In Nred10% in most of the cash crop and in the fodder crop counties UAA falls abandoned (cf. Map 3.4-3 d). In the model definition it is allowed to convert the area into set-aside area for which also direct payments are received. Although this activity is not restricted, the set-aside alternative is not used for all UAA (cf. Map 3.4-3 e), and consequently some UAA falls abandoned. However, with a gross margin of 60 EUR ha^{-1} set-aside activity should actually be extended and UAA should not fall abandoned. This unexpected reaction of land abandoning can be explained by model reaction, as already observed in the scenarios SUBred60% and SUBshift70% (cf. Section 3.2). As described in the subsidy reduction scenarios in Section 3.2 the optimal solution for the extend of production activities is found for the equilibrium of the gross margins of all activities. The reduction of cropping activities due to nitrogen constraints results in an optimum that requires the reduction of the complete UAA. Furthermore, the regional farm approach does not consider that the factor agricultural area can be re-allocated among the actors i.e., a working land market is not reflected (cf. Section 3.2).

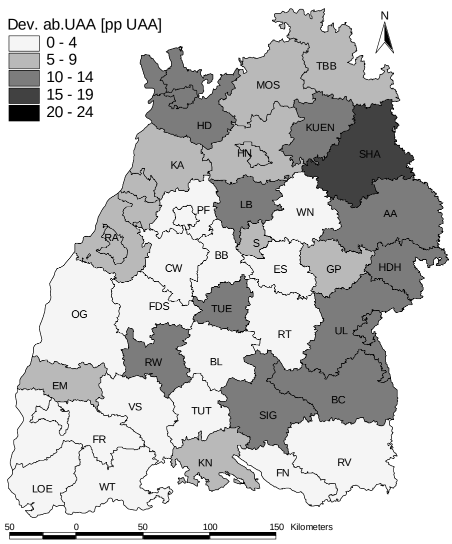
However, the land abandoning ranges from 4pp to 19pp of UAA and is for several NUTS3 counties higher than the acceptable range as it is defined in the subsidy reduction scenarios in this study. In the subsidy reduction scenarios the benchmark for the acceptable development of UAA is less than 10pp for the complete model region (cf. Section 3.2). Taking 10pp also as regional benchmark several NUTS3 regions reach or exceed this (e.g. HD, LB, SHA).

Map 3.4-3 c: Change of set-aside area Nred10% compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

Map 3.4-3 d: Change of abondened UAA area Nred10% compared to CAP2003.

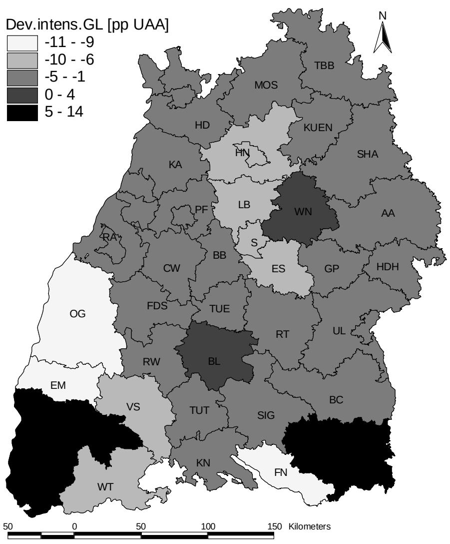


Notes: Unit: pp UAA, basis: REF.

Crop production intensity and animal production

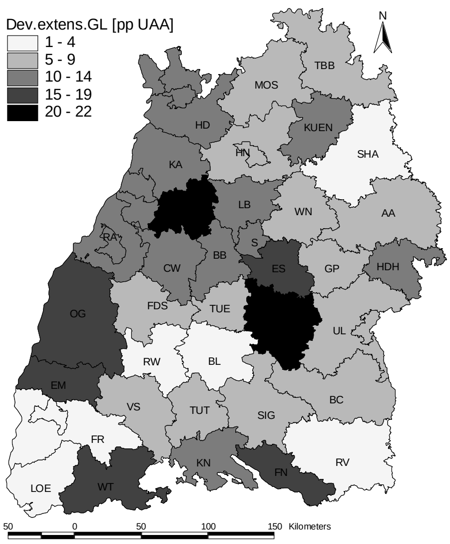
In Nred10% most of the counties tend to decrease intensive grassland area and convert it into extensive grassland, which requires less nitrogen fertilization (cf. Map 3.4-4 a, b). In intensive grassland counties, the intensive grassland area is extended (e.g. RV). Due to the nitrogen constraints in these counties cereals area is reduced since it is the most intensive crop produced. The cereals fodder lost for dairy cattle feeding is substituted by increased intensive grassland area.

Map 3.4-4 a: Change of intensive grassland in Nred10% compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

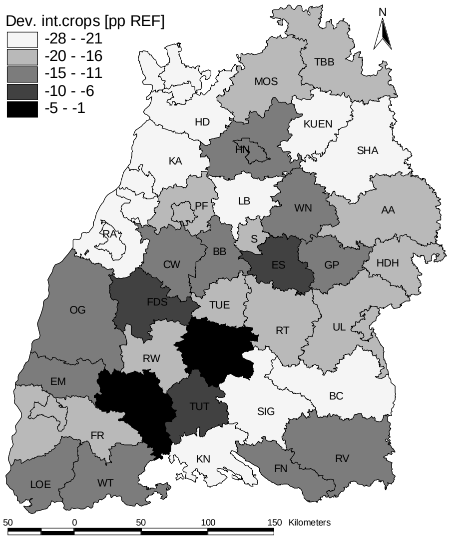
Map 3.4-4 b: Change of extensive grassland in Nred10% compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

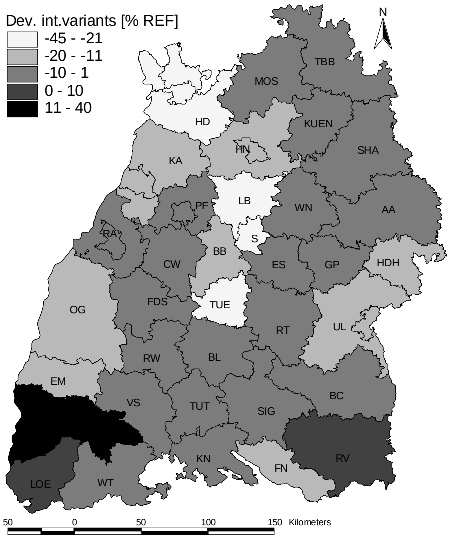
All counties tend to decrease the area of intensive crops and the area of intensive variants in the Nred10% scenario. Both reactions are the consequence of the constraints to reduce nitrogen input which results in decreased grassland intensity and decreased crop intensity. The increases of intensive variant area in the counties RV and in FR result from the increases of intensive grassland which replaces cereals area as fodder in dairy feeding (cf. Map 3.4-4 c, d).

Map 3.4-4 c: Change of intensive crop area in Nred10% compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

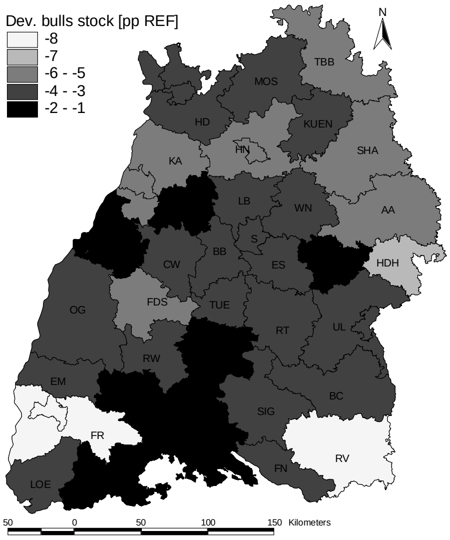
Map 3.4-4 d: Change of intensive variant area in Nred10% compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

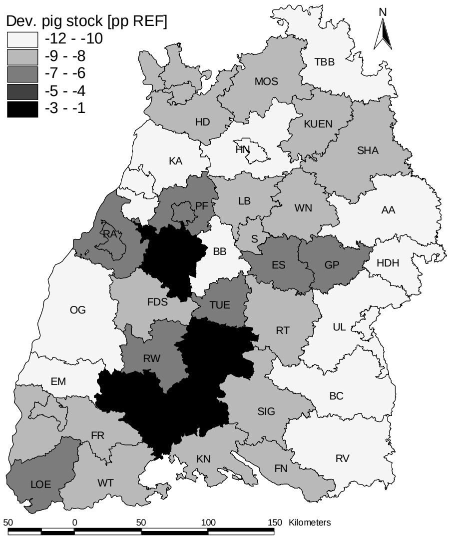
Livestock is reduced particularly in counties with high livestock density in order to reduce organic nitrogen. Thus, the decrease of fattening bulls stock and fattening pigs is highest in counties with high density of animals (e.g. HDH, RV) (cf. Map 3.4-5 a, b). Due to high gross margins dairy cow number are kept constant. To reduce nitrogen input production activities with small total gross margin are reduced first and the reductions in crop production and bull and pigs reduce the nitrogen input already sufficiently, and hence the number of dairy cows can be retained.

Map 3.4-5 a: Change of bulls stock in Nred10% compared to CAP2003.



Notes: Unit: %, basis: REF.

Map 3.4-5 b: Change of pig stock in Nred10% compared to CAP2003.



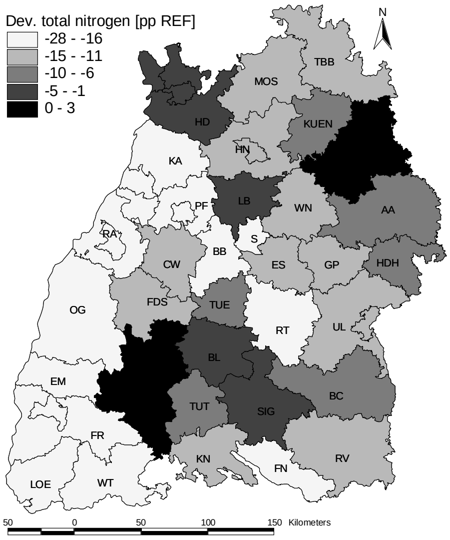
Notes: Unit: %, basis: REF.

Development of environmental indicator values

Nitrogen input, erosion potential and GHG emissions

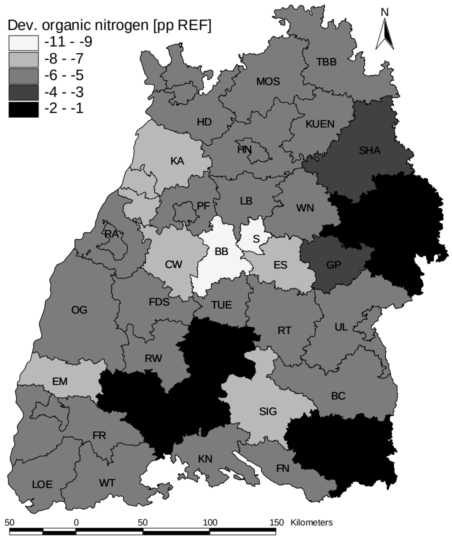
In Nred10% the intensity of total nitrogen input tends to decrease in almost all counties. Nitrogen intensity is the indicator representing environmental pressure due to nitrogen pollution. The increases of nitrogen input in SHA, RW and VS result from the reduction of UAA by land abandoning. In the model nitrogen intensity is calculated as the quotient of nitrogen divided by UAA under production, therefore the reduction of UAA by land abandoning results in an increase of the quotients in these counties, i.e. nitrogen intensity increases. The modelled nitrogen constraint is related to the total nitrogen input and forces a decrease of nitrogen input. Thus, the absolute level of nitrogen amount is decreased in all counties, although the intensity increased in some countries due to land abandoning. Therefore, some countries still show a high average nitrogen input per hectare not abandoned UAA, although the total amount of nitrogen input and thus production intensity is reduced (e.g. KUEN, SHA, UL, BC, RV, cf. Map 3.4-6 d).

Map 3.4-6 a: Change of total nitrogen input in Nred10% compared to CAP2003.



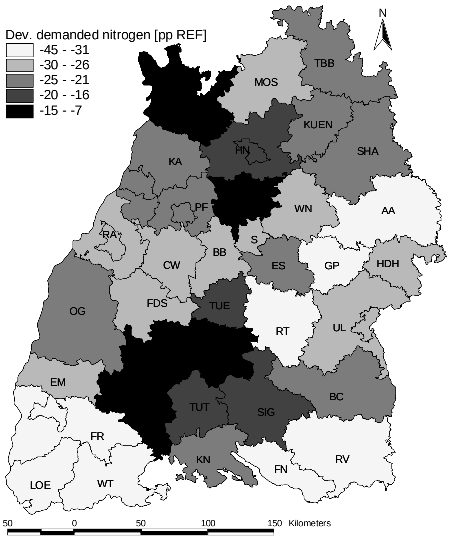
Notes: Unit: %, basis: REF.

Map 3.4-6 b: Change of organic nitrogen input in Nred10% compared to CAP2003.



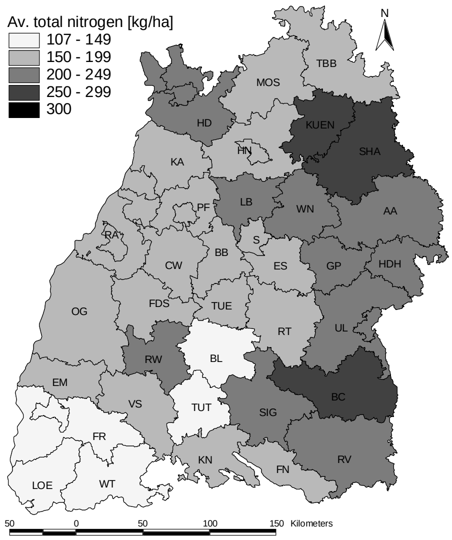
Notes: Unit: %, basis: REF.

Map 3.4-6 c: Change of demanded nitrogen input in Nred10% compared to CAP2003.



Notes: Unit: %, basis: REF.

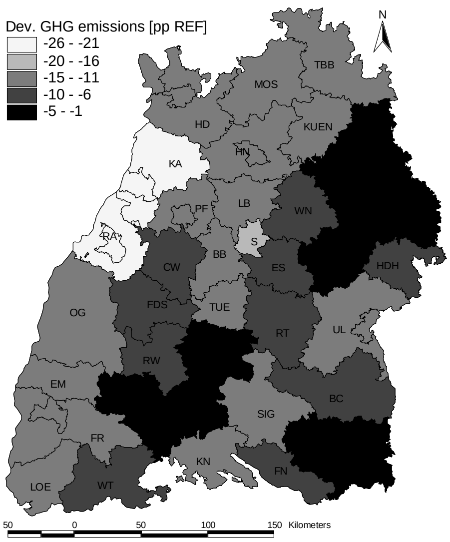
Map 3.4-6 d: Average nitrogen intensity in Nred10%.



Notes: Unit: kg N ha^{-1}, basis: REF.

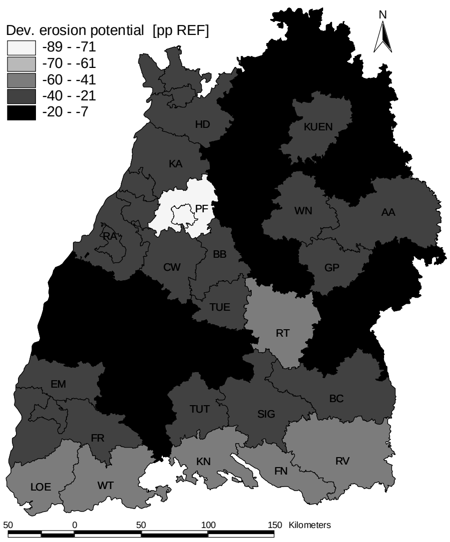
In the Nred10% scenario the erosion potential decreases significantly due to a strong extensification of crop production (cf. Map 3.4-6 f). GHG emissions are reduced due to the reduction of demanded nitrogen (e.g. in KA) and by the increased conversion of arable land into grassland (e.g. in RA). In grassland counties and fodder crop counties the GHG emissions are reduced due to a decrease in cattle stock (cf. Map 3.4-6 e).

Map 3.4-6 e: Change of GHG emissions in Nred10% compared to CAP2003.



Notes: Unit: %, basis: REF.

Map 3.4-6 f: Change of erosion potential in Nred10% compared to CAP2003.

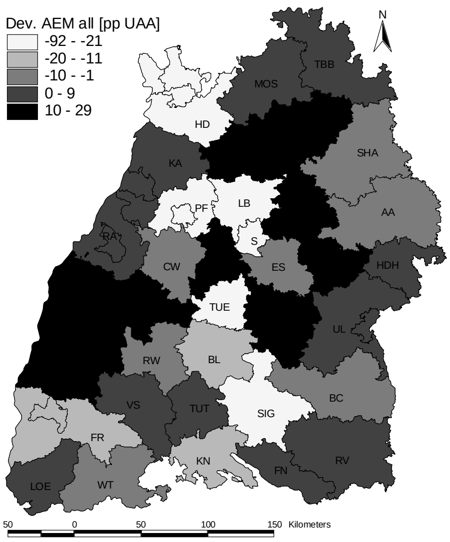


Notes: Unit: %, basis: REF.

Potential AEM area, weighted nitrogen input and weighted erosion potential

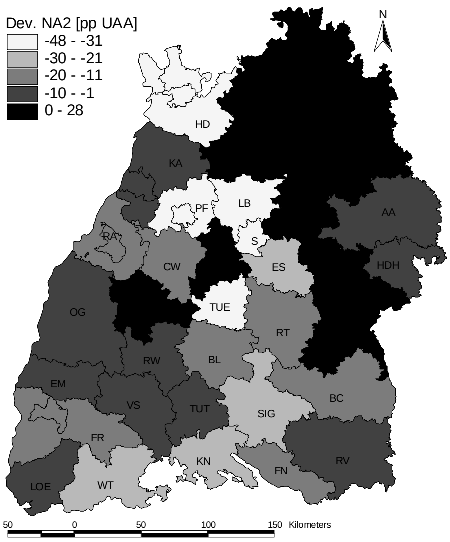
In Nred10% single counties show an extreme reduction of potential AEM area. The measures of reduced cattle intensity on grassland (NB-1 and NB-2, cf. Section 3.5) compensate each other, because intensive grassland is converted to extensive grassland area or vice versa. The reduction of potential AEM area results from the decrease of the AEM 'crop rotation with four crop groups' (NA2) and 'greening of arable area in autumn' (NE-2) which are only partially compensated by the increase of 'greening of set-aside area' (NE-3) due to increased set-aside area. A regional explanation requires a more detailed analysis of the situation in each county (cf. Map 3.4-7 a to d). For example in HD and LB the AEM area decreases due to a decrease in greening area according to the AEM 'greening of arable area in autumn' (NE-2) and 'greening of set-aside area' (NE-3). The decrease in both measures result from a decrease in cereals area (cf. Map 3.4-3 a).

Map 3.4-7 a: Change of potential AEM area in Nred10% compared to CAP2003.



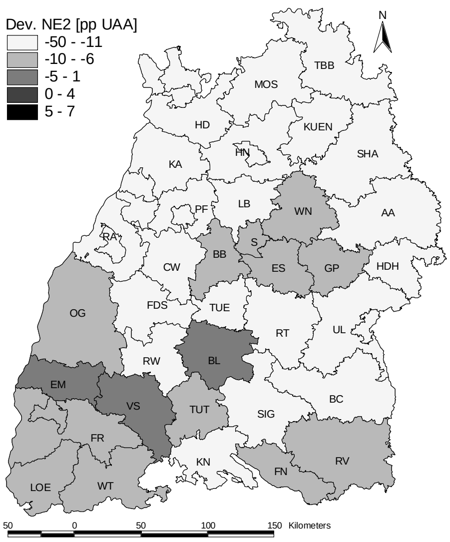
Notes: Unit: pp UAA, basis: REF.

Map 3.4-7 b: Change of potential NA-2 area in Nred10% compared to CAP2003.



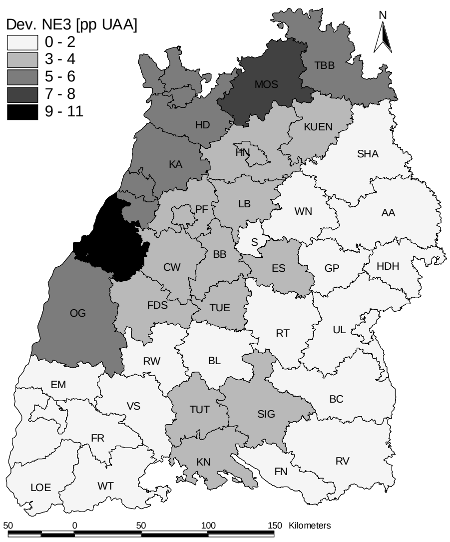
Notes: Unit: pp UAA, basis: REF.

Map 3.4-7 c: Change of potential NE-2 area in Nred10% compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

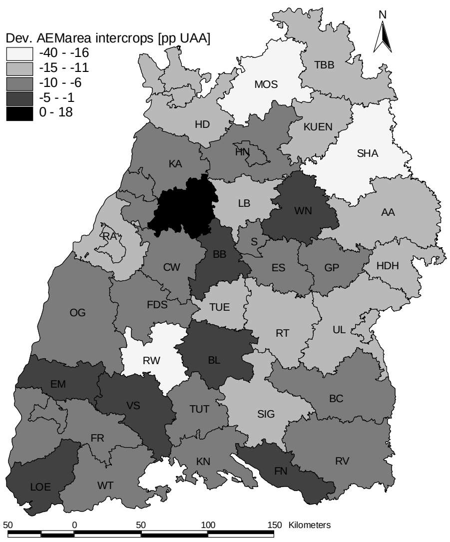
Map 3.4-7 d: Change of potential NE-3 area in Nred10% compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

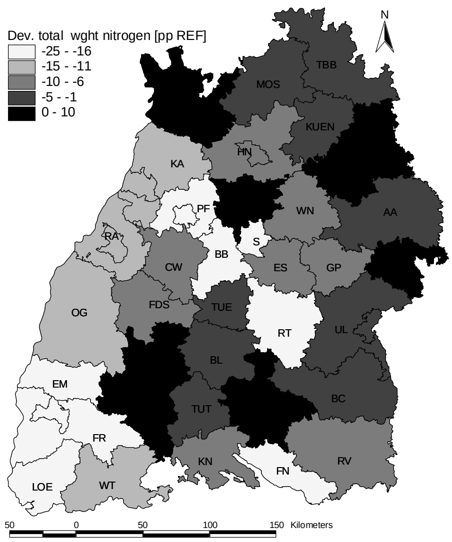
The area of the AEM activity intercropping is decreasing in Nred10% (cf. Map 3.4-8 a). The decreasing trend results from a decreasing arable area due to increased conversion of arable land into grassland and less conversion of grassland into arable land as well as due to land abandoning. The changes in intercropping area affect the weighted measures of nitrogen intensity and of erosion potential in most of the counties positively (e.g. PF) (cf. Map 3.4-8 b, c). However in some counties (e.g. HD and LB) the weighted nitrogen intensity increased due to a decrease in intercropping area.

Map 3.4-8 a: Change of intercrop area in Nred10% compared to CAP2003.



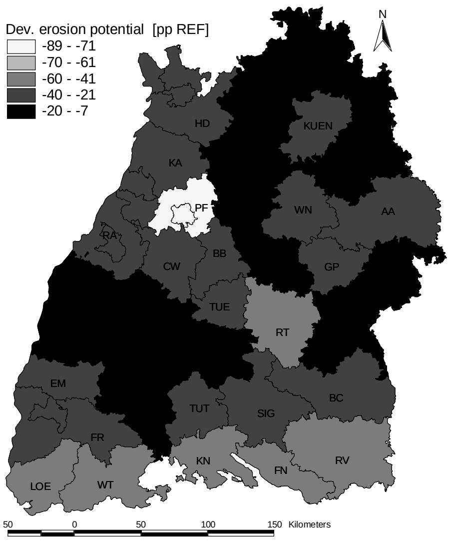
Notes: Unit: %, basis: REF.

Map 3.4-8 b: Change of weighted nitrogen input in Nred10% compared to CAP2003.



Notes: Unit: %, basis: REF.

Map 3.4-8 c: Change of weighted erosion potential in Nred10% compared to CAP2003.



Notes: Unit: %, basis: REF.

3.4.5 Analysis of indicator values according to farm types

In Nred10% the total nitrogen input is reduced by 10% compared to the reference situation. This threshold results in a significant extensification partially achieved by abandoning UAA, as can be observed particularly in AL-CC and AL-FC. Thus, subsidy volume and TGM decrease due to reduction of agricultural area and due to the loss of direct payments and gross margin. However, the losses of incomes range from 2 to 5pp and thus are relative small and in an acceptable range (cf. Section 3.4.4).

In all farm types, the restriction of nitrogen demand results in an extensification of crop and animal production and cereals and maize area are decreased while set-aside area and converted arable land are increased. Grassland is extensified and UAA falls out of production in nearly all farm types. In all farm types the number of bulls and pigs are decreased in order to decrease entrance of organic nitrogen. In the farm types the decreases in cereals production reaches from 7pp to 16pp, while the losses for bulls and pigs reaches from 3pp to 4pp, respectively from 5pp to 9pp (cf. Table 3.2-4). This means a significant reduction especially in cereals area.

Due to reduced agricultural production UAA falls abandoned which is in the complete model region with 7pp abandoned UAA still in an acceptable range of less than 10pp. However, in AL-FC the increase of abandoned UAA exceeds the upper benchmark defined for the subsidy scenarios (cf. Section 3.2) with a development of 10pp.

The decrease in indicator values of environmental pollution reflects the decrease of environmental pressure due to changes in production. The environmental objectives are affected more positively in the intensive farm types than in the extensive farm type GL-EG. The area under AEM is reduced in arable land farm types and kept constant or increased in grassland farm types.

Table 3.4-2: Development of indicator values in CAP2003 and Nred10%.

		CAP2003						Nred10%					
		AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]
SUB[m] volume	[pp]	25	29	41	57	55	36	-8	-12	1	-4	-3	-8
SUB volume Pillar 1	[pp]	14	21	67	96	73	34	-10	-13	-4	-8	-5	-10
SUB volume Pillar 2	[pp]	40	18	-29	-20	-7	2	0	-6	8	2	0	0
TGM[n] volume incl. SUB	[pp]	15	10	14	15	19	12	-5	-6	-2	-5	-3	-5
TGM volume excl. SUB	[pp]	13	6	9	7	6	7	-5	-5	-2	-6	-4	-4
Cereals	[pp][o]	7	10	2	4	3	6	-13	-16	-10	-7	-9	-12
Maize	[pp][o]	2	1	5	1	0	1	-2	-1	-1	-6	0	-1
Fodder crops	[pp][o]	0	1	0	0	1	0	-1	-2	-1	0	-2	-1
Others[p]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Root crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Oil seeds and legumes	[pp][o]	-4	-6	-1	-2	-5	-4	-1	-2	-1	0	0	-1
Set-aside area	[pp][o]	-4	-4	-3	-2	-3	-3	4	4	1	0	2	3
Conv. of grassland[q]	[pp][o]	2	2	3	1	1	2	-2	-2	-1	-3	-1	-2
Conv. of arable land[r]	[pp][o]	0	0	0	0	5	1	6	7	9	8	6	8
Intensive grassland	[pp][o]	-2	-2	-1	-2	-1	-1	-5	-3	-1	4	-3	-2
Extensive grassland	[pp][o]	1	0	-2	1	5	1	12	9	8	7	10	9
Abandoned UAA[s]	[pp][o]	0	0	0	0	0	0	7	10	4	2	3	7
Dairy cows	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Bulls	[%]	-5	-5	-6	-4	-3	-4	-4	-4	-5	-4	-3	-4
Fattening pigs	[%]	-15	-13	-13	-13	-17	-14	-9	-9	-9	-9	-5	-8
Intensive crop area	[pp][o]	6	7	7	5	2	5	-20	-21	-15	-13	-10	-17
Intensive variant area	[pp][o]	3	-1	0	0	-1	0	-17	-9	2	-5	-5	-8
Nitrogen total	[%]	12	12	10	8	7	10	-14	-9	-24	-13	-9	-12
Nitrogen total (weight.)[t]	[%]	-1	-6	7	-1	-4	-3	-9	-2	-22	-8	-5	-7
Nitrogen organic	[%]	-7	-6	-7	-4	-7	-6	-7	-5	-6	-4	-5	-5
Nitrogen demand	[%]	23	29	24	23	18	24	-22	-24	-39	-32	-21	-25
Erosion potential	[pp][u]	5	-2	18	1	-14	2	-36	-36	-44	-44	-24	-35
Erosion potential (weight.)[t]	[pp][u]	-8	-19	14	-7	-23	-10	-29	-27	-42	-39	-20	-28
GHG[v] emissions	[%]	4	1	1	-5	-4	-1	-15	-11	-13	-5	-7	-9
Potential AEM area[w]	[pp][o]	-7	-12	-7	0	-8	-19	-6	-9	4	6	-1	-2

Notes: a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percent share of UAA/percentage points of UAA compared to the share in reference situation. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare/difference in percent. u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. v: Potential in percent of uncovered arable land/difference in percent. w: Green house gas. x: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity.

3.4.6 Analysis of results according to achievement of policy objectives

The Nred10% scenario shows in the farm types impacts on economic, supply and environmental objectives. The objective of subsidy reduction is impacted positively in the intensive farm types AL-CC and AL-FC and in complete BW. Due to reduced agricultural activities on less UAA payments are received than in CAP2003. Income stability is impacted negatively in AL-CC, AL-FC and GL-FC and not impacted in GL-IG and GL-EG. However, the range of losses can be considered as acceptable (cf. Subsection 3.4.5).

Supply is in all farm types negatively impacted, particularly with respect to production of cereals and livestock. The objective of retaining UAA is impacted negatively in BW and in farm types AL-CC and AL-FC of which AL-FC exceed the acceptable range (cf. Subsection 3.4.5).

Due to the reduction of intensive agricultural production the environmental objectives are impacted positively in all farm types. However, the area of potential AEM is impacted positively only in the farm types GL-FC, GL-IG and GL-EG.

Table 3.4-3: Impact on policy objectives in Nred10%.

		Nred10%					
		AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]
SUB[m] volume	[pp]	+	++	0	0	0	+
SUB volume Pillar 1	[pp]	++	++	0	+	+	++
SUB volume Pillar 2	[pp]	0	+	-	0	0	0
TGM[n] volume incl. SUB	[pp]	-	-	0	-	0	-
TGM volume excl. SUB	[pp]	-	-	0	-	0	0
Cereals	[pp][o]	- -	- -	- -	-	-	- -
Maize	[pp][o]	0	0	0	-	0	0
Fodder crops	[pp][o]	0	0	0	0	0	0
Others[p]	[pp][o]	0	0	0	0	0	0
Root crops	[pp][o]	0	0	0	0	0	0
Oil seeds and legumes	[pp][o]	0	0	0	0	0	0
Set-aside area	[pp][o]	0	0	0	0	0	0
Conv. of grassland[q]	[pp][o]	0	0	0	0	0	0
Conv. of arable land[r]	[pp][o]	-	-	-	-	-	-
Intensive grassland	[pp][o]	-	0	0	0	0	0
Extensive grassland	[pp][o]	+ +	+	+	+	+ +	+
Abandoned UAA[s]	[pp][o]	-	- -	0	0	0	-
Dairy cows	[%]	0	0	0	0	0	0
Bulls	[%]	0	0	-	0	0	0
Fattening pigs	[%]	-	-	-	-	-	-
Intensive crop area	[pp][o]	+ +	+ +	+ +	+ +	+ +	+ +
Intensive variant area	[pp][o]	+ +	+	0	+	+	+

		Nred10%					
		AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]
Nitrogen total	[%]	++	+	++	++	+	++
Nitrogen total (weight.)[t]	[%]	+	0	++	+	+	+
Nitrogen organic	[%]	+	+	+	0	+	+
Nitrogen demand	[%]	+ +	+ +	+ +	+ +	+ +	+ +
Erosion potential	[pp][u]	+ +	+ +	+ +	+ +	+ +	+ +
Erosion potential (weight.)[t]	[pp][u]	+ +	+ +	+ +	+ +	+ +	+ +
GHG[v] emissions	[%]	+ +	+ +	+ +	+	+	+
Potential AEM area[w]	[pp][o]	0	0	+ +	+ +	+	0

Notes: a to d: Clustered counties with high shares of … a: … arable land and cash a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percentage points of utilized agricultural area compared to the share in reference situation. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. u: Percentage points difference from reference situation. v: Green house gas. w: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity.
+ small positive impact on objective, ++ medium positive impact on objective, +++ highest positive impact on objective
- small negative impact on objective, - - medium positive impact on objective, - - - highest positive impact on objective, 0: no impact on objective

3.4.7 Scenario discussion

The two scenarios Nred170kgN and Nred10% simulate the reduction of nitrogen input following the WFD and the OSPAR conventions. The assumption for both scenarios is the mandatory reduction of agricultural nitrogen input coming from mineral and organic fertilization. The potential to model such nitrogen reduction scenarios is limited in ACRE, and this limitations are considered in the following discussion.

Discussion regarding the scenario modelling

Modelling of optimized fertilization

The model ACRE does not optimize nitrogen fertilization according to the best allocation of nitrogen applied by mineral fertilizer or by manure. The objective function in ACRE considers the fertilization activity by adding the costs for mineral fertilizer demanded by crop activities and adding the monetary value of nitrogen from manure. In the goal function the fertilization part is simplified displayed as follows:

Total gross margin =
revenue – other costs […]
*[…] – acreages crop activity * crop specific nitrogen demand*
** nitrogen price + livestock activity*
** animal specific organic nitrogen production * nitrogen price […]*

Eq. 3.4.2

This formulation does not ensure an optimal allocation of the input of mineral nitrogen and organic nitrogen. It rather represents a selling activity of manure for the price of the nutrients, than the optimized application of farm manure. The impact of changes in nitrogen price would be of interest but would require the consideration of a nitrogen balance. Thus, from a natural science point of view, the nitrogen entrance is modelled in a very simplified way. All influencing factors of soil and climate conditions are not represented, which makes it problematic to interpret the changes in the nitrogen indicator values.

Modelling of the regulations for nitrogen reduction by constraints

It can be questioned whether the selected restrictions of Nred170kg and Nred90% are appropriate to represent the simulated regulations. In the Nred170kg scenario the selected restriction of 170 kg organic nitrogen per hectare on which manure is applied, does not show any significant impact on agricultural production. This is because the applied 'regional farm approach' implies the aggregation of all production factors in the region, and this results in an 'aggregation error'. The calculation of the organic nitrogen intensity in the NUTS3 counties considers the total UAA of the region, and this is so large that the restriction of 170 kg nitrogen per hectare is not reached at NUTS3 level.

Table 3.4-4 presents the intensity of organic nitrogen in the reference situation, baseline scenario, Nred170kg and Nred10%. The intensity of organic nitrogen is in all scenarios lower than the defined benchmark of maximum organic nitrogen input. This means with the calculated intensities there is no problem with respect to the regulation, because the restriction is not binding at NUTS3 level. However, in reality the restriction can be binding at farm level, i.e. have implications for individual farms which in turn could then also affect agricultural production at regional level. Thus, the regional farm approach at NUTS3 level might not be the most suitable approach to simulate the legislation of the WFD. The definition of a lower benchmark for the organic nitrogen intensity could simulate more realistic situation. However, this definition requires further investigation of the regional nitrogen intensities in Baden-Wuerttemberg in order to transfer the organic nitrogen intensity at NUTS3 level to an adequate level that represents the situation of nitrogen intensity at farm level.

Scenario Nred10% simulates the situation of nitrogen reduction according to the OSPAR convention, assuming that the regulation forces regional farms to reduce their nitrogen input by 10%. The global target of the OSPAR convention is to reduce nitrogen emissions to riverine systems. The assumption of reducing nitrogen input at NUTS3 county level seems to be appropriate since riverine systems require a regional monitoring. However, it might be questionable if such a regulation would be realistic since producers would be forced to reduce their nitrogen input and the production intensity drastically, thus such a regulation could be in contradiction with the CAP objectives to ensure agricultural income and supply (cf. Section 2.1).

Table 3.4-4: Intensities of organic nitrogen in reference situation, in baseline scenario and in Nred170kg and Nred90%.

	Reference situation	Baseline scenario	Nred170kg	Difference Nred170kg minus Baseline	Nred90%	Difference Nred90% minus baseline		Reference situation	Baseline scenario	Nred170kg	Difference Nred170kg minus Baseline	Nred90%	Difference Nred90% minus baseline
	[kg ha^{-1}]		[kg ha^{-1}]		[kg ha^{-1}]			[kg ha^{-1}]		[kg ha^{-1}]		[kg ha^{-1}]	
S	54	36	39	3	43	6	FDS	83	66	66	0	72	6
BB	61	42	42	0	44	2	FRsk	68	57	57	0	55	-2
ES	87	66	66	0	69	3	FR	68	57	57	0	55	-2
GP	109	95	93	-1	97	2	EM	77	65	65	0	67	1
LB	66	49	49	0	60	11	OG	71	58	58	0	62	4
WN	107	93	92	-1	101	7	RW	87	75	70	-5	75	0
HNsk	45	33	33	0	41	8	VS	93	85	83	-2	89	4
HN	45	33	33	0	41	8	TUT	76	62	60	-2	63	1
KUEN	109	73	73	0	87	14	KN	82	61	59	-2	66	6
SHA	127	103	101	-1	114	12	LOE	71	61	61	0	60	-1
TBB	61	36	37	0	46	9	WT	85	70	68	-1	67	-3
HDH	95	73	73	0	92	18	RT	91	69	69	0	71	2
AA	108	86	86	0	101	15	TUE	49	35	36	2	37	3
BAD	38	27	28	0	34	7	BL	56	45	46	0	45	0
KAsk	29	21	20	-1	25	4	ULsk	102	69	69	0	81	12
KA	29	21	20	-1	25	4	UL	102	69	69	0	81	12
RA	38	27	28	0	34	7	BC	136	97	98	1	110	13
HDsk	55	40	40	0	48	8	FN	108	84	84	0	83	-1
MAsk	55	40	40	0	48	8	RV	151	135	135	0	138	3
MOS	70	46	46	0	55	9	SIG	103	75	75	0	82	6
HD	55	40	40	0	48	8							
PFsk	59	44	42	-2	44	0							
CW	86	71	71	-1	71	-1							
PF	59	44	42	-2	44	0							

Remarks for policy implications

Results of the scenario simulating the WFD by a constraint for organic nitrogen input of at maximum 170 kg N ha^{-1} do not show impacts on the policy objectives. However, the results at regional NUTS3 level are not necessarily representative for the impacts on agriculture at smaller scaled regional level (i.e. municipality and farm scaled level). Thus, the results calculated in this study can not be considered as sufficient to conclude for policy implications of the scenario 170 kg N ha^{-1}. The observed decreases in organic nitrogen input result from a decrease of animal numbers due to the CAP 2003 reform policies (i.e. the reduction of payments for animals).

Aiming at the target of the OSPAR convention to reduce the nitrogen input by 10% results in positive impacts for environmental objectives but in negative impacts for agricultural income and production. Thus, the instrument simulated in Nred10% is in contradiction with the CAP objectives to ensure agricultural income and production. The impact on subsidy reduction is positive because the extent of agricultural activities for which payments from Pillar 1 and 2 are received is reduced. The negative impacts on income and supply objectives are found particularly in the arable land farm types which dominate the model region and are of high importance for the supply of agricultural products. According to the income benchmark defined in the subsidy reduction scenario, the losses in income can be regarded to be in an acceptable range. However, it has to be considered that the high level of total gross margin is reached due to high direct payments according to the CAP2003 scenario as well as due to assumptions of increased prices and yields. The losses in cereals and animal production are of significant magnitude and could result in an undersupply of agricultural products as well as in abandoning of UAA in some counties.

In order to aim at the reduction of nitrogen emissions, while at the same time ensuring income stability and supply objectives, the general restriction of nitrogen input might not be the appropriate measure. Rather, a specific restriction should be defined for the regions (or farms) which respects the competitive relation of the policy objectives (cf. Section 2.1) and results in an acceptable pay-off between reaching environmental objectives and losses in income and reaching supply objectives. Defining regional (or farm) specific benchmarks would be comparable with the special approval of the application of 230 kg organic N ha^{-1} instead of 170 kg organic N ha^{-1} (cf. Subsection 3.4.2). Furthermore, additional instruments could be introduced to reduce the negative impact on income and supply (e.g. by compensation payments).

3.5 Mandatory AEM scenario

This chapter describes the simulation of a scenario which considers the environmental objective of applying agri-environmental measures (AEM) and extending the area under AEM. One scenario has been simulated in which selected AEM of the MEKA3 program are supposed to be mandatory for the producers. The scenario has been done by introducing modelling constraints which drive the model to apply AEMs. The following chapters present the scenario background (Subsection 3.5.1) and the scenario assumptions (Subsection 3.5.2). The modelling of the scenario is described in Subsection 3.5.3. The Subsections 3.5.4 and 3.5.5 present the analysis of the results according to NUTS3 counties as well as according to farm types. A scenario discussion follows in Subsection 3.5.6.

3.5.1 Scenario background

In the CAP 2003 reform the direct payments are structured in Pillar 1 and Pillar 2. Pillar 2 concerns rural development and is differentiated in four axis (cf. Section 1.1). Axis 2 contains policy measures aiming at the development of environment and countryside (cf. Section 1.1), comprising agri-environmental programs (AEP). AEP are regional policy measures in Germany applied at federal state (NUTS1) level. The federal state Baden-Wuerttemberg promotes the introduction and retaining of environmental friendly agricultural practises in the framework of the AEP "Marktentlastungs- und Kulturlandschaftsausgleichs" (MEKA) (Market Relief and Landscape-Compensation) (cf. MLR 2010).

Since the 90ies the importance of agri-environmental measures as instruments of agri-environmental policy and environmental protection has been increased. For environmental concerns, Member States (MS) paid allowances (since 1987) for farming in environmentally problematic regions by applying agri-envrionmental programs (AEP), co-financed by the EEC. In 1992 MEKA started as EU pilot project and resulted in a significant increase of environmental relevant extensification measures. Since then MEKA is in Germany as well as in the EU regarded as an exemplary agri-environmental program. In the first years of the introduction of MEKA also measures of market relief were considered while nowadays MEKA represents (only) the program for agri-environmental measures in Baden-Wuerttemberg. With the third revision (i.e. MEKA3) the measures are adapted to current requirements. MEKA3 is embedded within the framework of the "Massnahmen- und Entwicklungsplan Laendlicher Raum" 2007-2009 (MELP2) and it is co-financed by the EU (cf. Osterburg and Stratmann 2002, MLR 2010).

Basically in MEKA environmental services from agricultural production are monetarily compensated, which implies e.g. a more environmental friendly production than according to the standard management requirements (SMR) of good agricultural practise. The size of the payments is oriented to compensate for losses due to higher costs or lower yields resulting from the application of farm management requirements and shall be an incentive to motivate farmers for participation despite higher production risks. The participation in MEKA3 is voluntary for farmers and temporarily limited. Farmers can combine out of a pool selected AEM which are applicable for their farm (cf. Osterburg and Stratmann 2002, MLR 2010).

3.5.2 Scenario assumptions

In this scenario where mandatory AEM are simulated the restrictions defined below are considered in the optimization process. Similar to the nitrogen reduction scenario (cf. Section 3.4) this mandatory AEM scenario simulates a kind of statutory management requirement (SMR) as they are for example prescribed by cross-compliance. The scenario is based on two alternative or complementary assumptions: (a) it is assumed that producers are forced to apply AEM and/or (b) producers collectively apply AEM on a voluntary basis. Therefore the results of the scenario calculation can be interpreted in two ways: (1) The results illustrate the consequences of additional SMR which are mandatory and based on the measures of the agri-environmental program of MEKA3 (cf. Section 3.4). (2) The concept of agri-environmental programs is that farmers participate on a voluntary basis and that their participation is motivated by payments which (over-)compensate the costs of additional work input and losses due to decreased yields. The results illustrate the consequences of an optimized production under maximal extension of the AEM. So it is assumed that farmers have an own motivation for maximal extension of environmental friendly production and, the scenario reflects a self driven environmental friendly farming behaviour.

3.5.3 Scenario modelling

Farmers who participate in agri-environmental programs are obliged to apply AEM which aim at environmental friendly and extensive production. Modelling of AEM activities is associated with some difficulties, because it is not easy to treat AEM as the normal production activities (which are modelled under the assumption that they are aiming at the maximization of the total gross margin). The modelling problems result from the difficulty to formulate AEM activities in an optimisation model. AEM activities aim to achieve environmental objectives and these objectives are not necessarily associated with profit maximization. Thus, the simulation via supposing the maximization of total gross margin for this activity might be not appropriate. AEM are rather defined with respect to their application to improve the management standards than with respect to their resulting effects on production and environment. Furthermore, the PMP model approach requires historical data to calibrate the production activities. Data of regional crop yields, outcomes or positive external effects resulting from the application of AEM are not collected at NUTS3 county level. Thus, a calibration of AEM activities according to the PMP approach is not possible.

In practice the calculation of the payments for specific AEM is based on regional average costs, i.e. additional costs, losses and higher production risk, which are supposed to be compensated by payments for applying the AEM. Furthermore, it is allowed to pay an additional monetary incentive for the acceptance of higher production risk. This monetary incentive can be up to about 20% of the additional cost caused by the application of AEM (Osterburg 2002: 273). Therefore, it is difficult to survey or to estimate data on the real costs resulting from the application of AEM and data collections with such data are actually not available. Thus, while historical data of area under AEM can be retrieved from statistical data bases, the data of costs and yields for the calibration of the PMP model are missing.

Due to the lack of data AEM activities are modelled in ACRE in two different ways: (1) as 'real' activity in the optimization process and (2) as 'counted' activity not implied in the optimization process.

(1) Calibrated AEM activities which are included in the optimization process:

For these AEM activities empirical data are available and modelling is possible because the activities are included in the calibration process (cf. Section 2.3). It is assumed that farmers opt for these measures by including the compensation payments within their gross margin calculation of the activity. Three AEM activities and payments are included in optimization: the two crop variant activities intensive grassland farming and extensive grassland farming as well as the crop activity of intercropping. The calibrated AEM are 'AEM production activities', i.e. producing the products intensive and extensive grassland and intercrops. Being calibrated by costs, yields, area and shadow prices the AEM production activities contribute with gross margin to the goal function.

(2) AEM activities which are not considered in the optimization process:

For these AEM activities it is assumed that the direct payments compensate the costs (resulting from additional efforts and losses in production when applying AEM) exactly to zero in all regions. There is no empirical data on these AEM available for calibration, because these AEM are newly introduced by the regional agri-environmental program MEKA3 after the reference year 2000. Such AEM are for example extensive cattle farming or covering of set-aside area. These new AEM activities are only counted in the model approach by their area as indicator for potential AEM activities under optimized scenario conditions. AEM activities are rather management activities which are not contributing to the optimized output of the production model. They are describing how the production activities are managed. Without being calibrated by costs, yields, area and shadow prices the 'AEM management activities' are not part of the objective function and they do not contribute any gross margin. Thus, the AEM activities are similar to the indicator value calculations which are only counted and not considered with their AEM payments or costs in the optimization process. It can be assumed that the monetary AEM payments compensate for the efforts and losses and result in zero contribution to the goal function.

In the mandatory AEM scenario the two ways to model AEM activities are combined. Some AEM constraints are defined which force the model to extend the 'real' activities so that a maximum of AEM activities is possible. Some other AEM are just counted as indicators by the number of hectares of area to which the AEM can be applied. The considered AEM measure and the way they are modelled in the mandatory AEM scenario are described in the following paragraphs and summarized by Table 3.5-1.

Crop rotation of four crop groups (NA-2) and maximum share of 40% maize area

This activity represents the MEKA3 measure N-A2 ('Viergliedrige Fruchtfolge'). In ACRE for this AEM four crop groups are defined to be considered in the crop rotation by each 25% of arable land.The crop groups are:

- Crop group 1 (spring cereals): winter wheat, winter barley, triticale
- Crop group 2 (spring cereals): spring wheat, spring barley
- Crop group 3 (extensive cereals and fodder, intensive root crops): rye, oats, sugar beet, potatoes vegetable, clover
- Crop group 4 (maize and others): silage maize, grain maize, energy maize, oilseeds, legumes, set aside

In the scenario a constraint ensures that the area of the crop groups is at least as large as 25% of the arable land area. The restriction for maize area allows a maximum of 40% of arable area for the cumulated area of silage maize, grain maize and energy maize.

Restriction for extensive cattle farming (NB-2)

The AEM activity represents the AEM of extensive cattle farming, which is defined for a cattle density on grassland between 0.3 LU and 1.4 LU per ha total grassland, including both management intensities: extensive and intensive grassland. The constraint for this activity forces the model to extend cattle production on grassland only within the defined range.

Restriction for less extensive cattle farming (NB-1)

This activity is only counted and defined correspondingly to the restriction for NB-2 with a range from a cattle density on grassland between 0.3 LU and 2.0 LU per ha total grassland. AEM NB-2 ensures a cattle density in between 0.3 LU and 1.4 LU per ha total grassland. Thus, the management for NB-1 (between 0.3 LU and 2.0 LU per ha total grassland) is already fulfilled and a constraint for NB-1 would not be binding and consequently is also not defined as a restriction in the model approach.

Regional typical pastures (NC-4)

The AEM activity of regional typical pastures is only counted by the acreage of the production activity 'meadows', i.e. it is assumed that meadow is managed via AEM NC-4 for feeding regional typical livestock on this area.

Arable land covering by intercrops (NE-2)

This AEM activity considers covering arable land by intercrops. The covering of area by intercrops is defined for production area of the main crops: winter wheat, winter barley, spring barley, oat, rye, legumes and winter rapeseed. It is assumed that the intercrop activity takes place on the same area as the main crop produced. NE-2 is a calibrated AEM activity which is included in the optimization process. A constraint ensures that the area of the 'real' production activity intercropping is as large as all the area of the relevant main crops.

Greening of set aside area (NE-3)

This AEM activity considers the covering of set-aside area. The calibrated AEM production activity set-aside area considers in its formulation already the covering of set-aside arable land by greening crops. Set-aside is a calibrated AEM activity which is included in the optimization process. NE-3 is counted according to the extent of the set-aside activity.

Table 3.5-1: Overview and description of the measures which are defined as potential AEM area.

Abbrev-iation	**Description of the measure**	**Definition with respect to the activities/ → constraint or counted**
NA-2	Crop rotation with four crop groups	Four crop groups of the same share of area. Crop group 1: Winter cereals (winter wheat, winter barley, triticale) Crop group 2: Spring cereals (spring wheat, spring barley) Crop group 3: Root crops, vegetables and extensive cereals (sugar beet, potatoes, vegetables, rye, oat, clover) Crop group 4: Oilseeds, legumes, maize, and set-aside (winter rapeseed, legumes, sunflowers, silage maize, grain maize, corn-cob-mix, set-aside) → constraint
NB-1	Cattle density is between 0.3 and 2.0 LU per hectares	Number of cattle per ha grassland area → counted
NB-2	Cattle density is between 0.3 and 1.4 LU per hectares	Number of cattle per ha grassland area → constraint
NC-4	Regional typical pasture	Defined for the grassland used as meadows → counted
NE-2	Greening of arable area in autumn	Defined for the area of winter wheat, legumes, winter barley, spring barley, oats, winter rapeseed, rye, triticale → constraint
NE-3	Greening of set-aside area	Defined for set-aside area → counted

3.5.4 Analysis of indicator values according to NUTS3 counties

This section describes the development and the status of the economic, supply and environmental indicators in the scenario under the assumption of mandatory AEM. The analysis has been done at regional level for the NUTS3 counties where agricultural production is represented by 'regional farms'.

Development of economic and supply indicator values

In the mandatory AEM scenario the volume of subsidies only changes slightly (cf. Map 3.5-1 a). Total gross margin tends to decrease in counties with high cattle density (e.g. BC, RV) because of the restriction of extensive cattle production (NB-2, Cattle density is between 0.3 and 1.4 LU per hectares) (cf. Map 3.5-1 b). In PF the TGM increases by 8%. This reaction is a combined effect of a small basic value for the percentage change and changes in agricultural production. Since PF is with 1252 EUR ha^{-1} among the 6 lowest average TGM the reaction in percentage change is more sensitive than in counties with greater total gross margin. The data show that in PF fodder area and others crop areas are reduced and cereals area and intensive grassland are slightly extended (by +2pp and +8pp). Additionally PF shows the highest increase in intensive crop production variant area (+24pp) (cf. Map 3.5-3 d). Thus, this county reacts with an intensification of crop production due to the AEM constraints and results in a better total gross margin than without these constraints. Due to the intensification also nitrogen input increases, resulting in an increase of the weighted nitrogen indicator value.

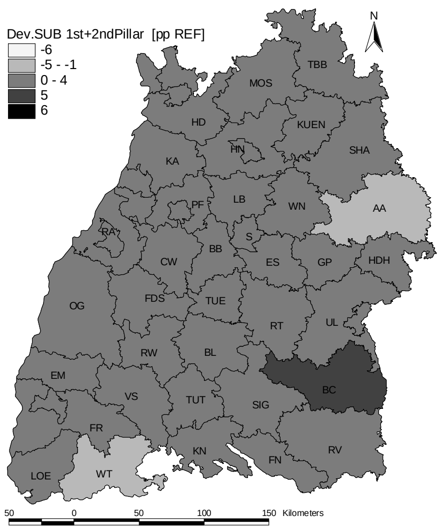
For the NUTS3 county TUT the model constraints provoke an intensification in crop production and a better optimal solution than given by the baseline policy, implying that the county TUT would profit from the policy as simulated in this scenario. However, since the AEM result in an intensification of production (i.e. an effect not intended by the policy measure) this observation has to be handled carefully.

Cereals production tends to decrease in nearly all counties due to the fulfilled four element crop rotation of the restriction (NA-2, crop rotation with four crop groups), particularly in fodder crop counties in the east of the study region (cf. Map 3.5-1 c).

Fodder crop production is reduced particularly in counties with highly decreased cattle stock (e.g. RV, BC) (cf. Map 3.5-1 d). Significant shares of arable land are converted into grassland in arable crop counties, especially in fodder crop counties (e.g. BC, AA). Here, the reduced fodder crop area is replaced by extensive grassland (Map 3.5-3 b).

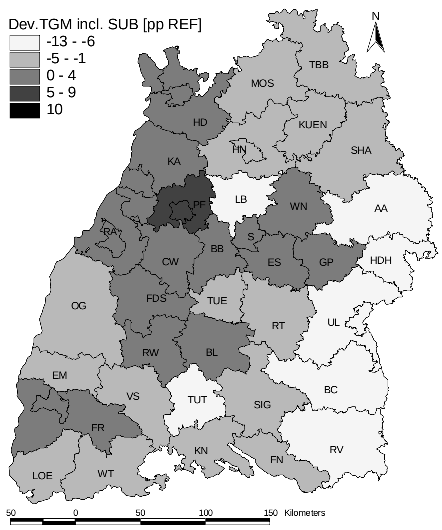
The driving restriction for the extension of extensive grassland is the lower and upper threshold for cattle stock on grassland (between 0.3 and 1.4 LU per ha). Only in few countries intensive grassland area is increased by changes from extensive area and conversion from arable land to grassland (e.g. AA, BC). In most of the counties extensive grassland is extended (cf. Map 3.5-1 e, Map 3.5-3 a). The conversion of arable land into grassland results in two effects: the increased grassland result in a decrease of cattle density, while the reduction of arable land makes it easier to fulfil the four element crop rotation (NA-2: 'crop rotation with four crop groups').

Map 3.5-1 a: Change of SUB in Pillar 1 and Pillar 2 in Mandatory AEM compared to CAP2003.



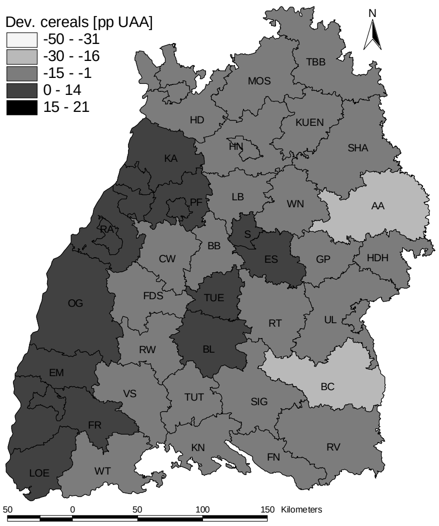
Notes: Unit: %, basis: REF.

Map 3.5-1 b: Change of TGM incl. SUB in Mandatory AEM compared to CAP2003.



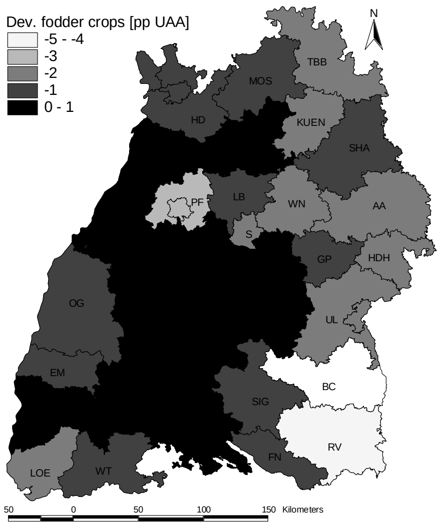
Notes: Unit: %, basis: REF.

Map 3.5-1 c: Change of cereals area in Mandatory AEM compared to CAP2003.



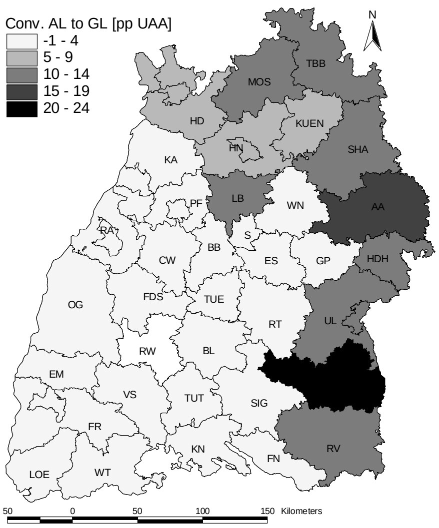
Notes: Unit: pp UAA, basis: REF.

Map 3.5-1 d: Change of fodder crop area in Mandatory AEM compared to CAP2003.



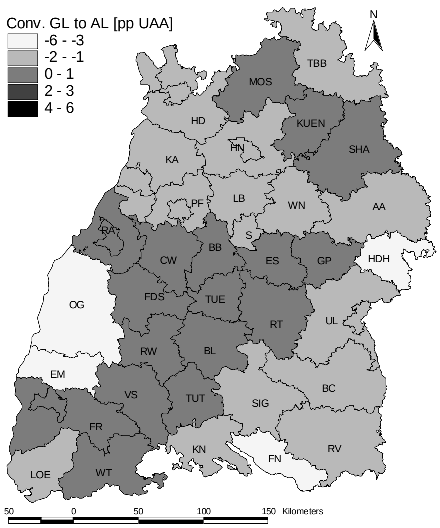
Notes: Unit: pp UAA, basis: REF.

Map 3.5-1 e: Change of converted arable area in Mandatory AEM compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

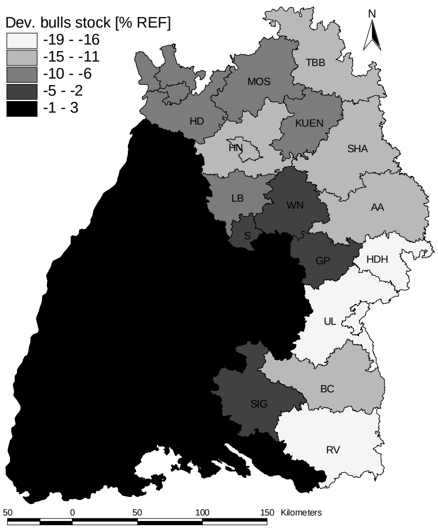
Map 3.5-1 f: Change of converted grassland area in Mandatory AEM compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

The extensification of cattle density to between 0.3 and 1.4 LU per ha grassland reduces the number of bulls significantly in arable counties of the north and the western part of the study region (e.g. HDH, UL). Because of their high gross margin dairy cow stock is affected just marginally and pig stock does not change either.

Map 3.5-2 a: Change of bull stock in Mandatory AEM compared to CAP2003.



Notes: Unit: %, basis: REF.

Intensive grassland tends to be shifted to extensive grassland in cash crop and fodder crop counties in the northern and the western part of the model region. An increase of intensive grassland is observed in counties where the reduction of cereals fodder is substituted by fodder from grassland (e.g. RV, LOE) (cf. Map 3.5-3 a, b).

Intensive crop area and intensive variant area tend to decrease in nearly all counties due to the reduction of arable land. Only few extensive counties of Schwarzwald and Schwäbische Alp produce on their small arable areas as much yield as possible by increasing the production intensity (Map 3.5-3 c, d).

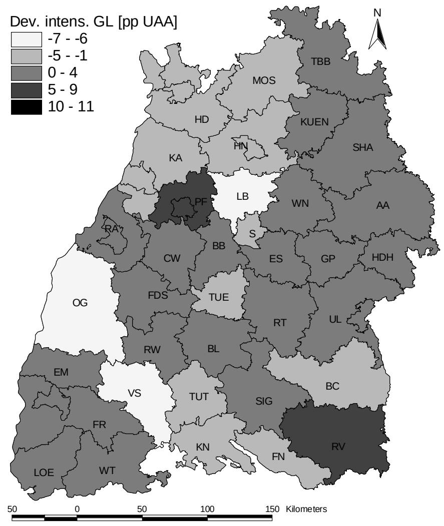
Development of environmental indicator values

Nitrogen input, erosion potential and GHG emission

In most of the counties nitrogen intensity tends to decrease or to be kept constant. The reduction results more from the decreased intensity of crop production than from the reduction of livestock. Only single counties show a slight increase of nitrogen input (cf. Map 3.5-4 a to c).

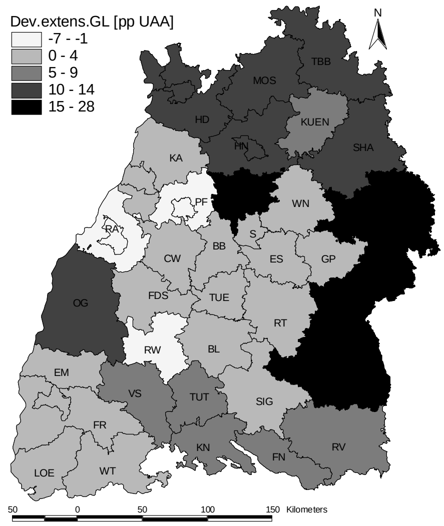
The erosion potential increases slightly in EG, due to the slight extension of other crops area. Other crops include winter rapeseed which has a high erosion potential compared to e.g. cereals (cf. Appendix 2.1) (cf. Map 3.5-4 e). GHG emissions decrease significantly due to decreased bull stocks and reduced enteric fermentation (Map 3.5-4 f).

Map 3.5-3 a: Change of intensive grassland in Mandatory AEM compared to CAP2003.



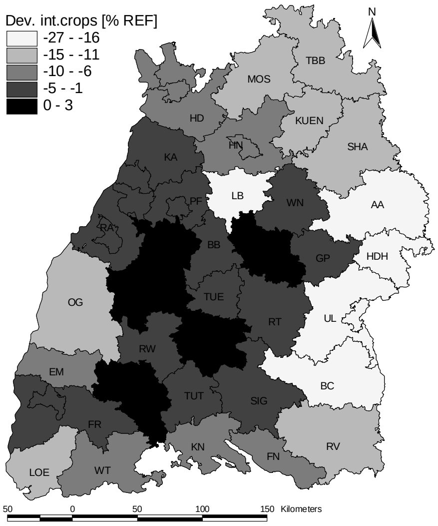
Notes: Unit: pp UAA, basis: REF.

Map 3.5-3 b: Change of extensive grassland in Mandatory AEM compared to CAP2003.



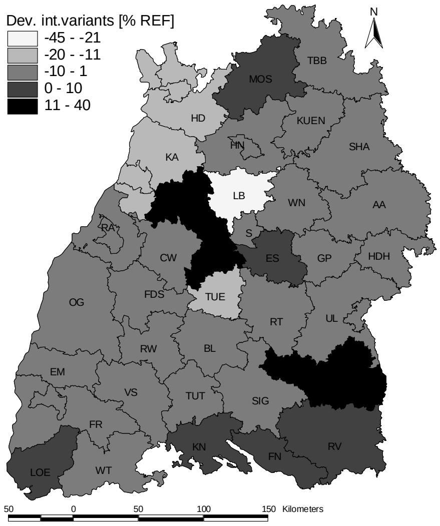
Notes: Unit: pp of UAA, basis: REF.

Map 3.5-3 c: Change of intensive crop area in Mandatory AEM compared to CAP2003.



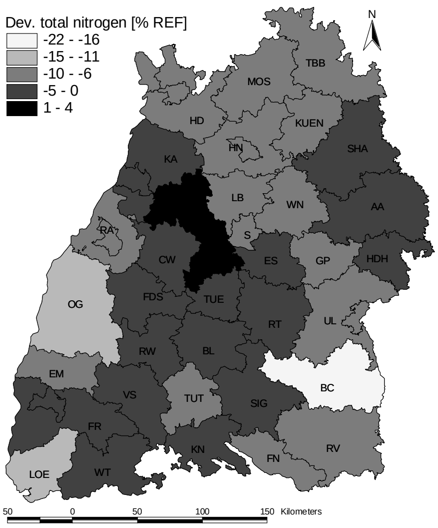
Notes: Unit: pp UAA, basis: REF.

Map 3.5-3 d: Change of intensive variant area in Mandatory AEM compared to CAP2003.



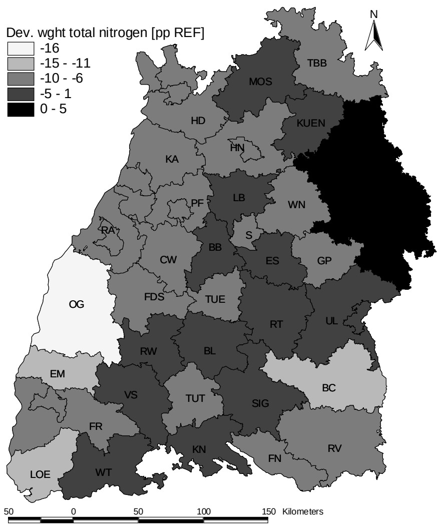
Notes: Unit: pp UAA, basis: REF.

Map 3.5-4 a: Change of total nitrogen input in Mandatory AEM compared to CAP2003.



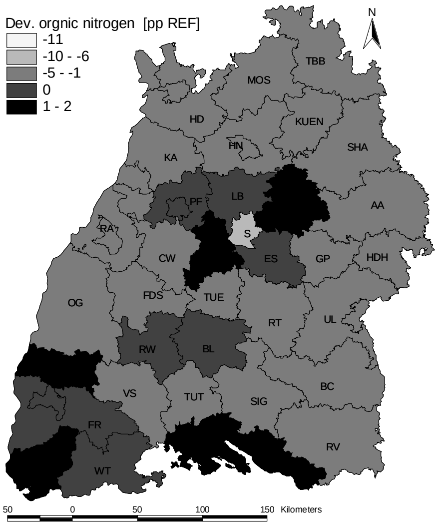
Notes: Unit: %, basis: REF.

Map 3.5-4 b: Change of total nitrogen input in Mandatory AEM compared to CAP2003.



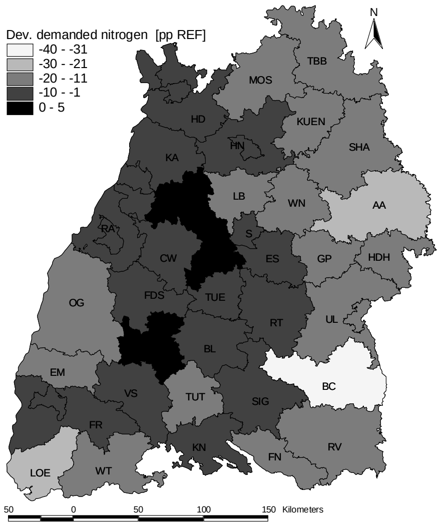
Notes: Unit: %, basis: REF.

Map 3.5-4 c: Change of organic nitrogen input in Mandatory AEM compared to CAP2003.



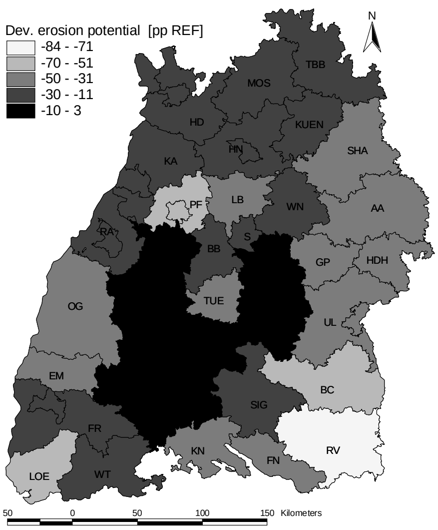
Notes: Unit: %, basis: REF.

Map 3.5-4 d: Change of demanded nitrogen input in Mandatory AEM compared to CAP2003.



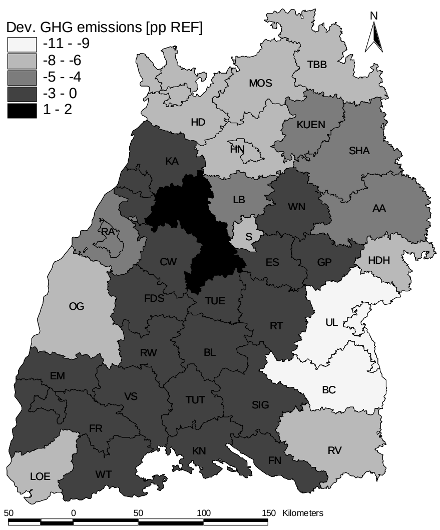
Notes: Unit: %, basis: REF.

Map 3.5-4 e: Change of erosion potential in Mandatory AEM compared to CAP2003.



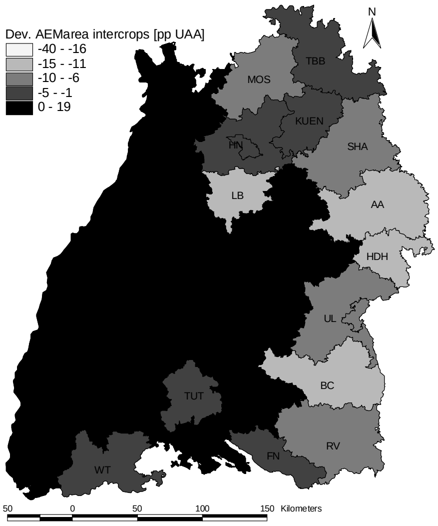
Notes: Unit: %, basis: REF.

Map 3.5-4 f: Change of GHG emissions in Mandatory AEM compared to CAP2003.



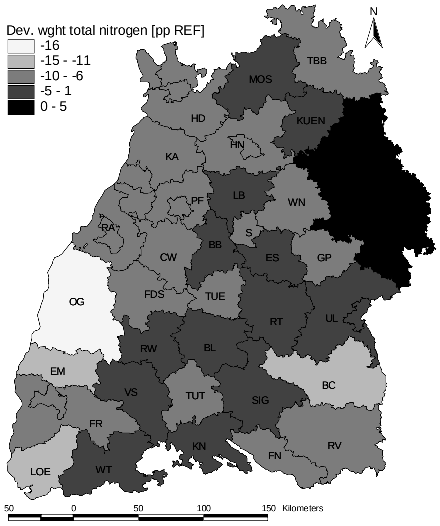
Notes: Unit: %, basis: REF.

Map 3.5-5 a: Change of intercrop area in Mandatory AEM compared to CAP2003.



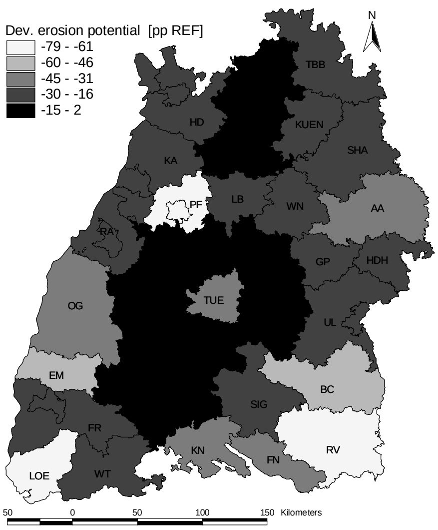
Notes: Unit: pp UAA, basis: REF.

Map 3.5-5 b: Change of weighted nitrogen in Mandatory AEM compared to CAP2003.



Notes: Unit: %, basis: REF.

Map 3.5-5 c: Change of weighted erosion potential in Mandatory AEM compared to CAP2003.

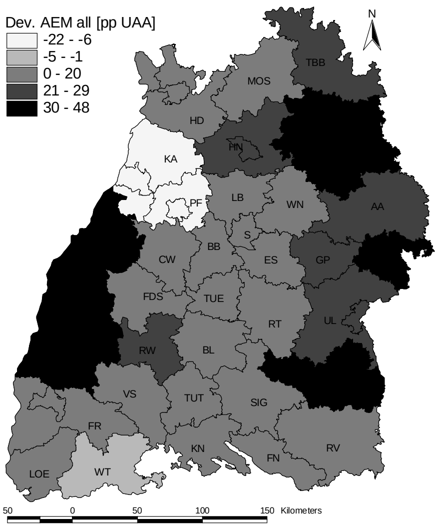


Notes: Unit: %, basis: REF.

Potential AEM area

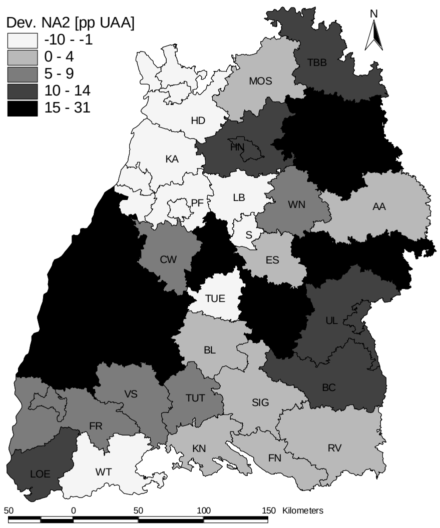
Maps 3.5-6 a to f present the changes of the potential area of AEM. In most of the counties the potential AEM area, which is the aggregated area of all AEM, is constant or increasing. While a constant AEM area indicates that the maximal extension of AEM is already reached in the baseline scenario, an increased area of potential AEM indicates that total AEM area is extended due to the scenario assumptions.

Map 3.5-6 a: Change of potential AEM area in Mandatory AEM.



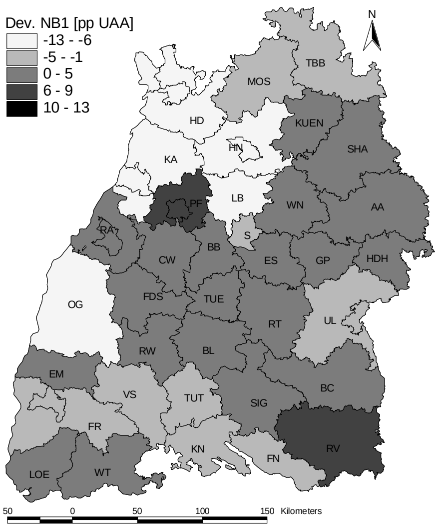
Notes: Unit: pp UAA, basis: REF.

Map 3.5-6 b: Change of potential NA-2 (Crop rotation with four crop groups area) in Mandatory AEM.



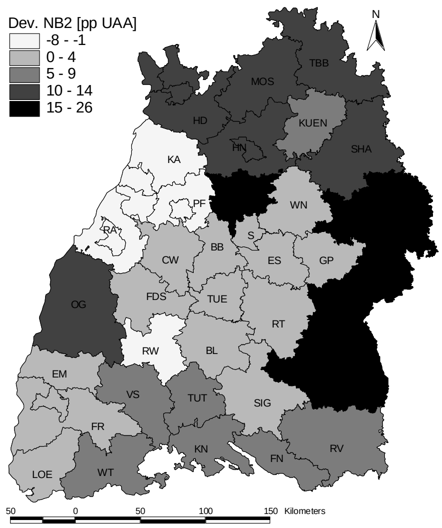
Notes: Unit: pp UAA, basis: REF.

Map 3.5-6 c: Change of potential NB-1 (cattle density is between 0.3 and 2.0 LU per hectares) area in Mandatory AEM.



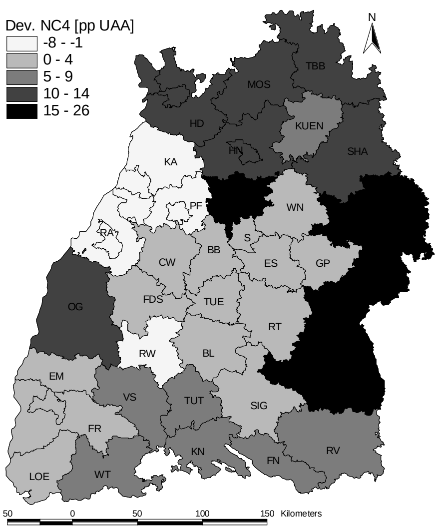
Notes: Unit: pp UAA, basis: REF.

Map 3.5-6 d: Change of potential NB-2 (cattle density is between 0.3 and 1.4 LU per hectares) area in Mandatory AEM.



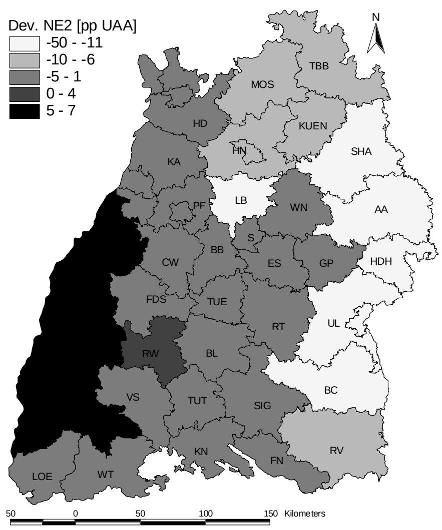
Notes: Unit: pp UAA, basis: REF.

Map 3.5-6 e: Change of potential NC-4 (regional typical pasture area) in Mandatory AEM.



Notes: Unit: pp UAA, basis: REF.

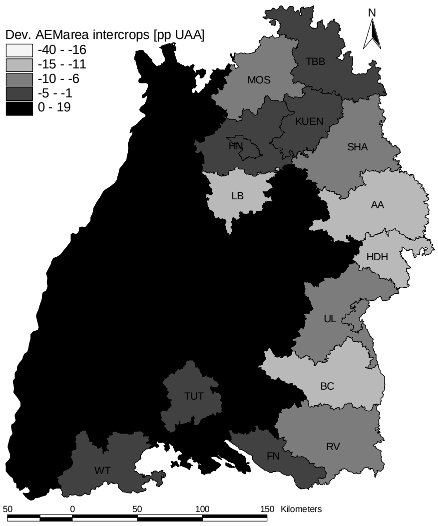
Map 3.5-6 f: Change of potential NE-2 (greening of arable area in autumn) area in Mandatory AEM.



Notes: Unit: pp UAA, basis: REF.

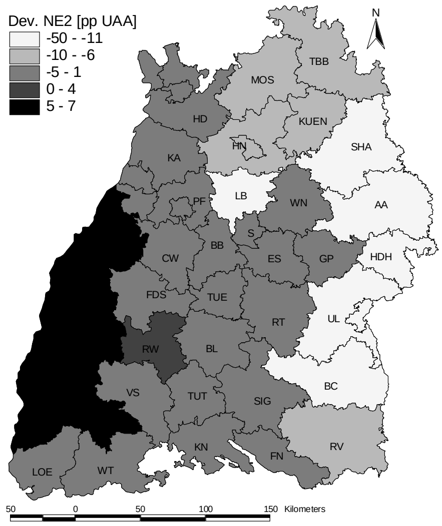
Beside the potential AEM area for the measure of intercropping in autumn, intercropping is also calculated as a 'real' AEM production activity in the optimisation process. Map 3.5-6 g shows that the deviations of intercropping area are similar to the deviations of the potential AEM area for NE-2 (cf. Map 3.5-6 g and Map 3.5-6 e (rep.). The acreage of the optimized intercropping activity is used to calculate the indicators of weighted nitrogen input and weighted erosion potential (cf. Map 3.5-6 h, i). The maps show that in most of the counties the weighted nitrogen input and erosion potential is unchanged or has decreased. The largest decreases in weighted nitrogen input and erosion potential can be rather explained by the decrease in crop area with high nitrogen demand and high erosion potential than by increase in intercrop area. For instance in BC and RV intercrop area decreased and the weighted indicators of nitrogen input and erosion potential decrease. In these counties the area of intensive crops silage maize, winter rapeseed and winter wheat is reduced significantly and thus, erosion potential and nitrogen demand is reduced. For the counties SHA and AA and for some counties in the Schwäbischen Alp and Schwarzwald and Unterland the respective values increased slightly.

Map 3.5-6 g: Change of intercrop area in Mandatory AEM.



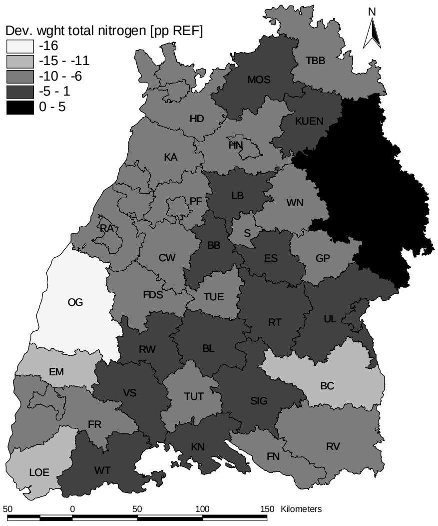
Notes: Unit: pp UAA, basis: REF.

Map 3.5-6 h (repeated): Change of potential NE-2 (greening of arable area in autumn) area in Mandatory AEM.



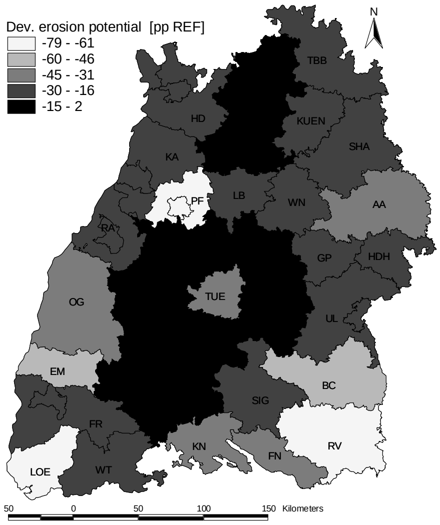
Notes: Unit: pp UAA, basis: REF.

Map 3.5-6 i: Change of weighted nitrogen input in Mandatory AEM.



Notes: Unit: %, basis: REF.

Map 3.5-6 h: Change of weighted erosion potential in Mandatory AEM.



Notes: Unit: %, basis: REF.

3.5.5 Analysis of indicator values according to farm types and achievement of policy objectives

The analysis of indicator values according to farm types shows that, as according to NUTS3 counties, in all farm types the subsidy volume is affected only marginally by the obliged AEM. The payments from Pillar 1 decrease slightly due to slightly reduced oilseeds area, which is entitled to special aids from the Pillar 1. However, the decrease of oilseeds is too small to be shown by the farm types data. The increase of payments from Pillar 2 results from the increase of converted arable land into grassland, from the extensification of grassland as well as from increases in intercropping activity. In all farm types the total gross margin decreases slightly by at maximum -4pp, this decrease results from the extensification of crop and animal production.

Cereals and maize area are reduced particularly in the fodder crops counties (AL-FC and GL-FC) and in all farm types arable land is converted into extensive grassland.

In all farm types except in GL-EG the constraint for NB-2 influences only slightly the number of dairy cows but extremely the number of bulls. Pigs are only reduced in GL-EG, because of decreased fodder cereals area (e.g. in TUT, cf. Map 3.5-2 b).

In all farm types the decreased intensity of agricultural production results in a decrease of the values of environmental indicators (e.g. nitrogen input decrease by -3 to -9pp) and increases the potential area for AEM significantly by +12pp to +26pp. GL-EG is the most extensive farm type in the baseline as well as in the mandatory AEM scenario. This farm type is less influenced by the mandatory AEM constraints but shows the highest increase of potential AEM area.

With respect to the impact on the achievement of policy objectives the result show that for BW the impact of mandatory AEM is negative on the subsidy volume for the Pillar 2, on total gross margin without subsidies and on production of cereals and bulls. The impacts on subsidy volume of Pillar 2 and total gross margin can be regarded as acceptable, since Pillar 2 payments increase with increased AEM area and the decreases in TGM are in an acceptable range. All the environmental objectives are impacted positively.

The impacts on production objectives are different in the farm types. AL-FC and GL-FC show the most extreme negative impacts on cereals and bulls production. GL-IG is even positively impacted on cereals production, while GL-EG is only impacted by a decrease in pig production. The environmental objectives are all impacted positively for all farm types particularly with respect to decreases in production intensity, reduced erosion potential and increased potential AEM area, as expected.

Table 3.5-2: Development of indicator values and impact on the achievement of policy objectives in Mandatory AEM scenario.

		indicator values according to farm types						impact on the achievement of policy objectives					
		AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	BW[g]
SUB[m] volume	[pp]	2	3	3	1	1	2	0	0	0	0	0	0
SUB volume 1st pillar	[pp]	-1	-1	-2	-3	0	-1	0	0	0	0	0	0
SUB volume 2nd pillar	[pp]	15	11	8	5	1	8	- -	- -	-	-	0	-
TGM[n] volume incl. SUB	[pp]	-1	-4	-1	-4	0	-4	0	0	0	0	0	0
TGM volume excl. SUB	[pp]	-2	-6	-1	-5	0	-5	0	-	0	-	0	-
Cereals	[pp][o]	-3	-11	5	-7	-2	-6	0	- -	+	- -	0	- -
Maize	[pp][o]	-1	0	-7	0	0	-1	0	0	-	0	0	0
Fodder crops	[pp][o]	-1	-2	-1	-2	0	-1	0	0	0	0	0	0
Others[p]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Root crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Oil seeds and legumes	[pp][o]	0	0	0	-1	2	0	0	0	0	0	0	0
Set-aside area	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Conv. of grassland[q]	[pp][o]	-1	-2	-1	-1	0	-1	0	0	0	0	0	0
Conv. of arable land[r]	[pp][o]	4	11	1	8	0	7	0	- -	0	- -	0	- -
Intensive grassland	[pp][o]	-2	-1	1	2	-1	-1	0	0	0	0	0	0
Extensive grassland	[pp][o]	7	14	1	7	1	9	+	++	0	+	0	+
Abandoned UAA[s]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Dairy cows	[%]	-1	-1	0	-1	0	-1	0	0	0	0	0	0
Bulls	[%]	-5	-9	1	-8	0	-7	-	-	0	-	0	-
Fattening pigs	[%]	0	0	0	0	-10	0	0	0	0	0	- -	0
Intensive crop area	[pp][o]	-8	-14	-7	-11	0	-10	-	++	+	+ -	0	++
Intensive variant area	[pp][o]	-4	2	2	-2	-1	-1	0	0	0	0	0	0
Nitrogen total	[%]	-6	-8	-9	-6	-3	-8	+	+	+	+	0	+
Nitrogen total (weight.)[t]	[%]	-6	-4	-11	-4	-4	-6	+	0	++	0	0	+
Nitrogen organic	[%]	-2	-2	1	-1	-1	-2	0	0	0	0	0	0
Nitrogen demand	[%]	-9	-17	-16	-17	-6	-14	+	++	++	++	+	++
Erosion potential	[pp][u]	-29	-35	-42	-45	-1	-31	++	++	++	++	0	++
Erosion potential (weight.)[t]	[pp][u]	-27	-28	-44	-40	-2	-27	++	++	++	++	0	-++
GHG[v] emissions	[%]	-4	-7	-4	-3	-1	-5	0	+	0	0	0	+
Potential AEM area[w]	[pp][o]	15	26	21	15	12	19	++	++	++	++	++	++

Notes: a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percent share of UAA/percentage points of UAA compared to the share in reference situation. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare/difference in percent. u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. v: Potential in percent of uncovered arable land/difference in percent. w: Green house gas. x: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. + small positive impact on objective, ++ medium positive impact on objective, +++ highest positive impact on objective

3.5.6 Scenario discussion

The presented scenario assumes that all of the farms participate in AEM programs and extend their AEM area as much as possible, either forced by law or on a voluntary basis. Due to a lack of data different modelling methods have been applied to simulate AEM activities. However, the simulated scenario includes two problems with regard to the modelling approach: (1) The AEM restrictions and indicators are not all considered as 'real' AEM production activities in the optimization approach (only intensive and extensive grassland and intercropping). (2) The AEM activities are modelled by three different modelling methods, which makes the approach somewhat inconsistent. The AEM activities intensive grassland, extensive grassland and intercropping are included in the optimization process, implying that farmers consider these measures in their optimization behaviour. These three measures are calibrated by the PMP method and thus modelled in a consistent way with the other crop production activities.

The second one of the three modelling methods derives the AEM activities from the acreage of production activities. Therefore, the extent of the AEM activity is just counted like an indicator and represents the potential AEM area. However as being counted from the extent of production activities these AEM activities are not included in the optimization process. It is assumed that the payments the farmers receive for applying the AEM are equal to the costs of applying the AEM, i.e. the net benefit is zero. In reality this assumption might not be fully realistic, because there should be at least a small monetary incentive for the farmer to include AEM into the production program. Nevertheless, this kind of indicator represents the area on which AEM can potentially be applied.

The third modelling method consists of model constraints, which force the model to consider some defined limits of production. These constraints force ACRE to extended AEM activities, suggesting that farmers are obliged to comply with these AEM activities.

The modelling exercise in this chapter was an attempt to model AEM activities with a PMP model. The problem of lack of data was tried to be overcome by using different modelling methods, which made the approach to some extent inconsistent. There is need for further modelling research to simulate activities influenced by payments for Pillar 2. Due to the weaknesses of the modelling approach the scenario with mandatory AEM is not considered in the following scenarios, which basically combine all the other scenarios from the former chapters.

3.6 Extensive and intensive agricultural production scenarios

The scenarios of extensive and intensive agricultural production entail a combination of the assumptions of the scenarios introduced in the Sections 3.2 to 3.4. The results of the previous sections give information on the impacts if only one single policy instrument is applied and simulated, the combined scenarios in this section allow to analyse what happens if a combination of policy instruments is introduced at the same time. Therefore the different policies of the previous scenarios are combined and represent two scenarios: one scenario with extensive agricultural production (EXT) and another with intensive agricultural production (INT). The following subsections describe the scenario background (Subsection 3.6.1) and the scenario assumptions (Subsection 3.6.2). The modelling of the scenario is explained in Subsection 3.6.3. The Subsections 3.6.4 and 3.6.5 present the analysis of the results according to NUTS3 counties and according to farm types respectively. A scenario discussion follows in Subsection 3.6.6.

3.6.1 Scenario background

The scenario assumptions of the combined scenarios are derived from the scenarios presented in Sections 3.1 to 3.5 which assume the policy of the CAP 2003 reform plus modified other policy or market measures. While in each of the scenarios in the previous subsections the impact of only one single policy measure is investigated separately, the combined scenarios simulate the implementation of a combination of several measures, impacting and interacting in parallel. In combination the policy instruments in such a policy mix can result in different impacts on the achievement of policy objectives in the counties than when simulating the implementation of each policy measure separately. The policy measures of the scenarios from the previous sections are combined in a way to represent the path of two possible policy and market scenarios which could be expected for the future: one combined scenario which provokes extensive agricultural production (EXT); another combined scenario which provokes intensive agricultural production (INT).

3.6.2 Scenario assumptions

In both scenarios it is assumed that the general objectives of agricultural policy are: reduction of subsidies (economic objective), production of food and energy crops (supply objective), and a reduction of nitrogen input (environmental objective). Even though the general policy issues are the same in both scenarios, the scenarios differentiate in the priorities given to the objectives. Therefore, the objectives are addressed by the implementation of different policy instruments. In addition the demand for bioenergy is assumed to differ in both scenarios due to different energy demands.

Scenario of extensive agricultural production (EXT)

The scenario assumptions of the EXT scenario represent a political and economic environment which is oriented towards an extensive agricultural production with respect to environment and energy. In detail the following assumptions are underlying: The objectives of subsidy reduction, income stabilization and ensuring agricultural production are of high priority and are addressed by a flatrate payment from Pillar 1. The objective to promote the application of AEM is also of high importance and is addressed by the extension of direct payments from Pillar 2 (shifting payments from Pillar 1 to Pillar 2). This application of reducing payments in Pillar 1 and increasing Pillar 2 payments is also simulated in the scenario SUBshift70% (cf. Section 2.2).

The scenario assumes a moderate demand for energy crop production and the policy priority for bioenergy production in agriculture is ranked as medium. It is assumed that energy policy and technological progress provoke an increase in supply of renewable energies produced outside the agricultural sector (e.g. solar energy or wind energy). Improvements of energy saving technology (e.g. energy isolations in buildings, economic engines) also result in a decreased demand for agriculturally produced energy. Thus, energy crop production competes only weakly with food production, i.e. only a small share of UAA is used for energy crop production while large shares are used for food production. The competiveness of energy crop production with food production is simulated by the calibration method used in scenario EmaizSM (cf. Section 3.3).

The priority for environmental issues is set to be high in this scenario. It is assumed that within the CAP a reduction of nitrogen input is prescribed according to the objective of the OSPAR conventions. The application of the policy instrument to reduce the nitrogen input by 10% is simulated in the scenario Nred90% (cf. Section 3.4).

Scenario of intensive agricultural production (INT)

The story line of the INT scenario represents a political and economic environment which is less oriented towards environmental and energy issues but more towards an intensive agricultural production. In detail the following assumptions are underlying: The priority of reduction of subsidies under income stabilization and ensuring agricultural production is high, however the priority of the application of AEM is middle. A flatrate payment from Pillar 1 is paid to ensure agricultural production and to stabilize agricultural income. The application of this instrument is simulated in the scenario SUBred60% (cf. Section 3.2).

Demand for energy crop supply is assumed to be high due to only small progress in supply of renewable energies produced outside the agricultural sector and small progress in energy saving technologies. The competitiveness of energy crop production with food production is assumed to be high and a large share of UAA is used for energy crop production. The competiveness of energy crop production is simulated by the calibration method used in scenario EmaizWW (cf. Section 3.3).

The priority for environmental issues is set to be low. Standard management requirements are oriented according to WFD and prescribe the limit of applied nitrogen input by 170 kg N ha^{-1} (cf. Section 3.4).

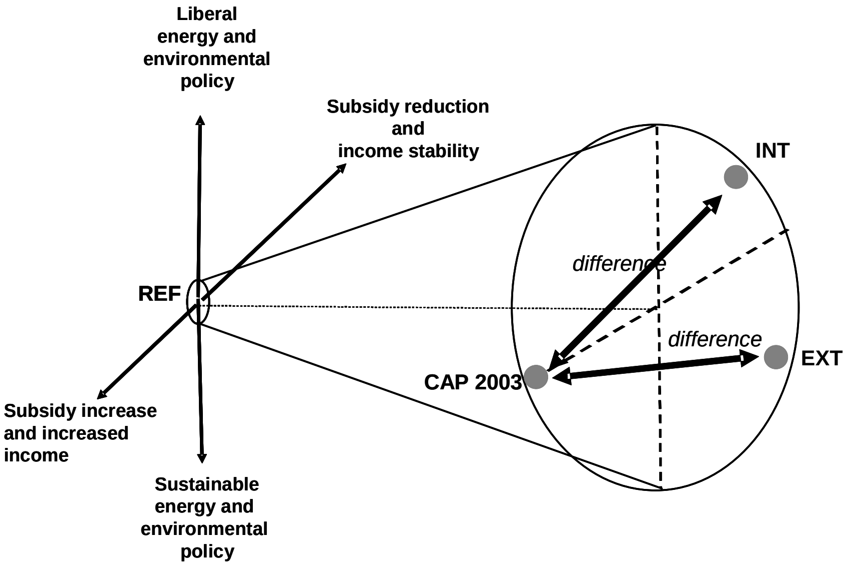
Figure 3.6-1 presents the scenarios EXT and INT and the orientation of their assumptions graphically by a scenario funnel. The reference year is represented in the origin of the funnel. The distance between the origin to the end of the funnel represents the period of 15 years; the area of the circle represents the scenarios in the target year of 2015.

The four dimensions indicate different policy directions. The vertical axis represents the directions of environmental policy and energy policy, which drive the energy demand. The horizontal axis represents the direction of subsidy policy and income stability.

The baseline scenario is CAP2003 and aims at income stability by increased subsidies and no energy policy with a medium importance on environmental policy. Both combined scenarios EXT and INT represent policies aiming at the reduction of subsidies but differ with respect to their energy and environmental policy. [49]

[49] In the standard illustration in the scenario funnel the baseline scenario is represented by the line between the origin and the centre funnel bottom. The policy scenarios are represented by the points within the circle, which illustrate the different orientations. According to this illustration in this study the middle of the bottom would represent the reference year prescribed in the scenario year 2015.

Figure 3.6-1: Illustration of the positions of scenarios CAP2003, EXT and INT in the scenario funnel.



Notes: INT = Scenario of intensive production, EXT = Scenario of extensive agricultural production. CAP2003 = baseline scenario.

3.6.3 Scenario modelling

The scenarios EXT and INT are combined by the scenarios introduced in the Sections 3.1 to 3.4, thus the scenario modelling can be described concisely by Table 3.6-1 which displays the scenarios EXT and INT with their objectives, priorities and the instruments.

Table 3.6-1: Objectives, priorities and policy instruments of the scenarios EXT and INT.

Objectives	**Sub objectives**	**EXT**		**INT**	
		Priority/ demand	**Policy instrument**	**Priority/ demand**	**Policy instrument**
Economic objectives	Subsidy reduction	high	SUBshift70%	high	SUBred60%
	Income stability	high	SUBshift70%	high	SUBred60%
Supply objectives	Food production	high	SUBshift70%	middle	SUBred60%
	Energy production	middle	EmaizeSM	high	EmaizeWW
	Retaining of UAA	low	SUBshift70%	middle	SUBred60%
Environmental objectives	Reduction of Production intensity	high	Nred10%	low	Nred170kg
	Environmental pollution	high	Nred10%	low	Nred170kg
	AEM area	high	SUBshift70%	middle	SUBred60%
Scenario/combined scenario	**Policy instrument**				
SUBshift70% / EXT	Subsidies from Pillar 1 are reduced by 70% and these subsidies are transferred to Pillar 2 for AEM				
SUBred60% / INT	Subsidies are reduced from Pillar 1 by 60%				
EmaizeSM / EXT	Energy maize competes weakly with food crops (coarse grains), regionally distributed energy maize production				
EmaizeWW / INT	Energy maize competes strongly with food and fodder crops (winter wheat), locally focussed energy maize production				
Nred10% / EXT	Nitrogen reduction according to OSPAR convention. Nitrogen amount is reduced by 10% of the nitrogen amount in the reference year				
Nred170kg / INT	Application of the Water Framework Directive (WFD): maximal nitrogen amount from manure 170 kg N ha^{-1}				

3.6.4 Analysis of scenario indicator values according to NUTS3 counties

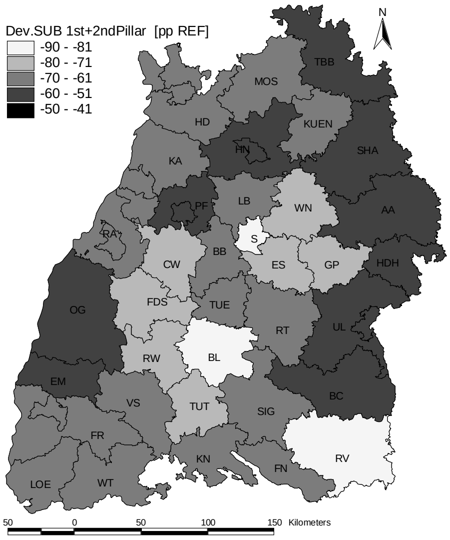
Development of economic indicator values

Both scenarios show a decrease in subsidy volume. The losses of total subsidies are larger in scenario EXT than in INT due to larger shares of abandoned UAA (which consequently does not receive direct payments). Due to the redistribution of direct payments from Pillar 1 to Pillar 2 the decrease in subsidy volume is larger in scenario EXT than in INT in the north western counties (e.g. KA, HD) and smaller in the north eastern fodder crop counties (e.g. SHA, AA). In the arable crop counties KA and HD less direct payments are redistributed to arable area than to grassland because payments for AEM on grassland are larger than on arable land. In these arable counties the reduction of subsidies in EXT is larger than in INT because the reduction by 70% with shifting of subsidies to Pillar 2 results in smaller payments than the reduction by 60% without shifting payments. The average subsidy volume appears to be more homogenously distributed in INT than in EXT (cf. Map 3.6-1 c, d).

In both scenarios all counties decrease their TGM. The differences result from differences in energy maize production and nitrogen fertilization. In scenario INT the TGM decreases particularly in counties with high shares of cereals area (e.g. KA). Higher demand for energy crop supply let replace cereals by energy maize, which has a higher gross margin than cereals. Due to the reduction of nitrogen input by 10% in scenario EXT a decrease of animals is especially forced in counties with high animal density (e.g. SHA, BC, RV) which results in a larger reduction of TGM than in scenario INT.

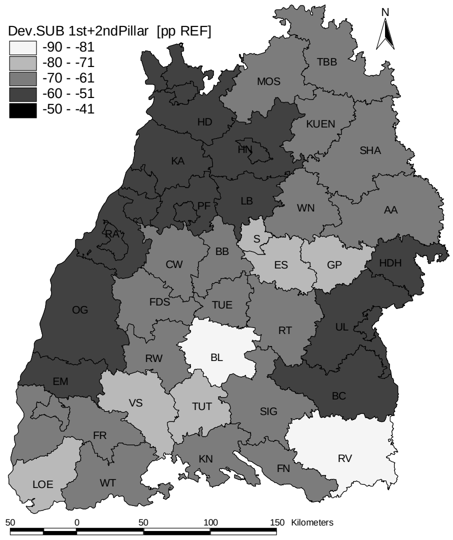
The distribution of average TGM is similar in both scenarios. Extensive grassland counties (e.g. in Schwarzwald, or Schwäbische Alp) and arable counties show smaller average TGM than counties with high animal production (e.g. SHA, RV) or with high share of special crops (e.g. S, LB, OG). Due to the high specific gross margin of animal and special crop production the average total gross margin is high (cf. Map 3.6-1 g, h).

Map 3.6-1 a: Change of SUB Pillar 1 and Pillar 2 in EXT compared to CAP2003.



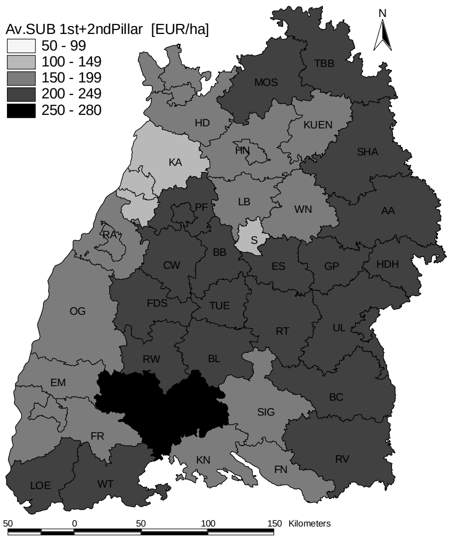
Notes: Unit: %, basis: REF.

Map 3.6-1 b: Change of SUB Pillar 1 and Pillar 2 in INT compared to CAP2003.



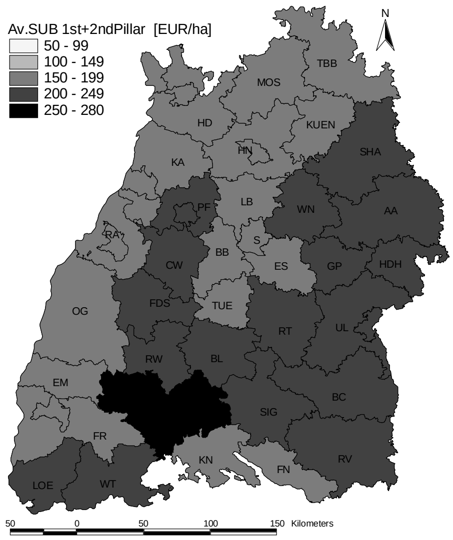
Notes: Unit: %, basis: REF.

Map 3.6-1 c: Average SUB in Pillar 2 in EXT compared to CAP2003.



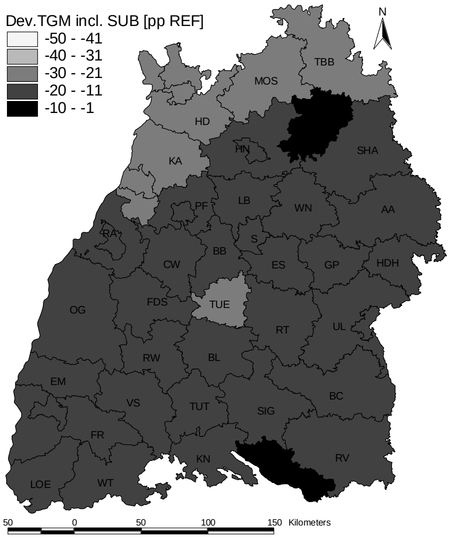
Notes: Unit: EUR ha^{-1}, basis: REF.

Map 3.6-1 d: Average SUB in Pillar 2 in INT compared to CAP2003.



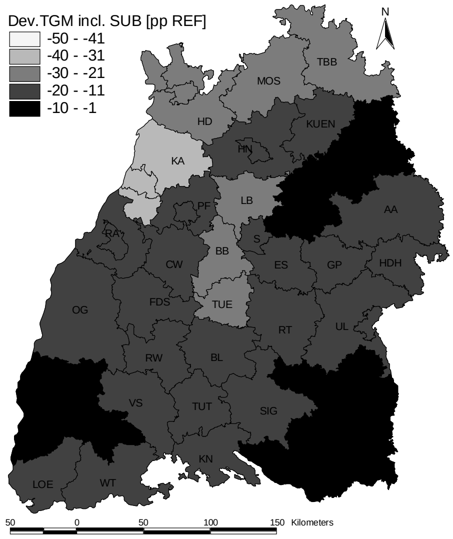
Notes: Unit: EUR ha^{-1}, basis: REF.

Map 3.6-1 e: Change of TGM incl. SUB EXT compared to CAP2003.



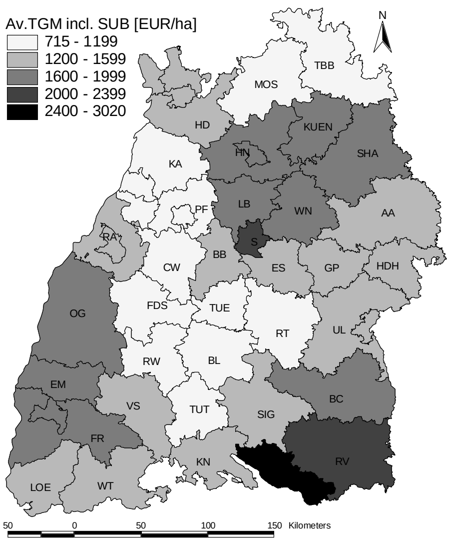
Notes: Unit: %, basis: REF.

Map 3.6-1 f: Change of TGM incl. SUB in INT compared to CAP2003.



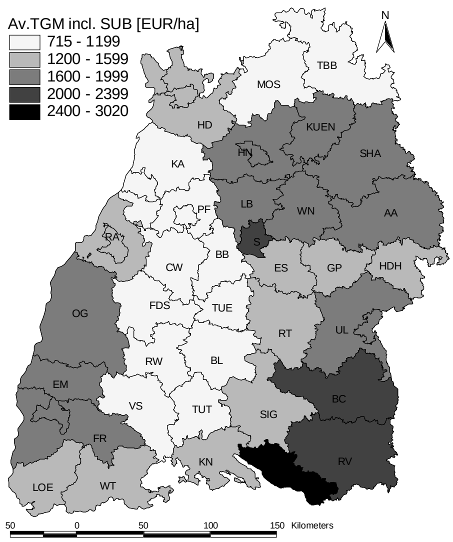
Notes: Unit: %, basis: REF.

Map 3.6-1 g: Average TGM incl. SUB in EXT compared to CAP2003.



Notes: Unit: EUR ha^{-1}, basis: REF.

Map 3.6-1 h: Average of TGM incl. SUB in INT compared to CAP2003.



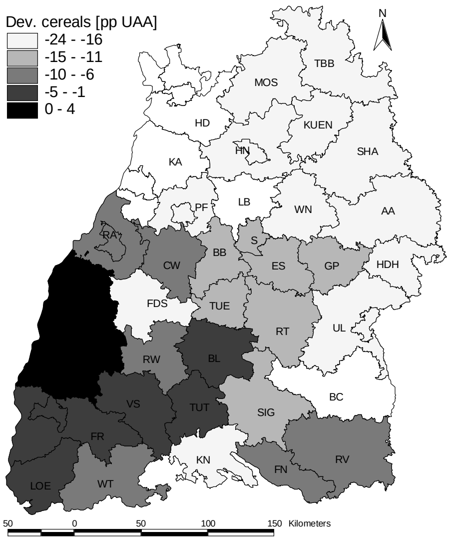
Notes: Unit: EUR ha^{-1}, basis: REF.

Development of supply indicator values

In scenario EXT cereals area is reduced significantly because of the reduction of nitrogen by 10% compared to the reference amount. The nitrogen restriction affects especially the northern part of the model region. In scenario INT the cereals area decreases due to the expansion of energy maize area (cf. Map 3.6-2 a, b).

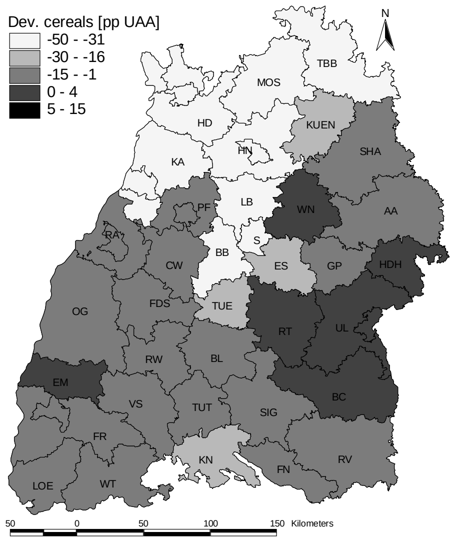
In scenario EXT the energy maize area is smaller than in scenario INT and replaces only small shares of cereals and also fodder crops area (cf. Map 3.6-2 e, f). In both scenarios highest shares of energy maize area are in the arable counties where production conditions result in high maize yields. Grain maize area decreases partially, however the total maize area extends due to the increased energy maize production (cf. Maps 3.6-2 g to j).

Map 3.6-2 a: Change of cereals area in EXT compared to CAP2003.



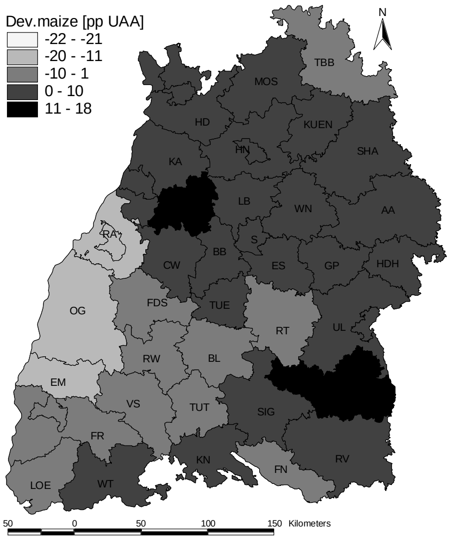
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 b: Change of cereals area in INT compared to CAP2003.



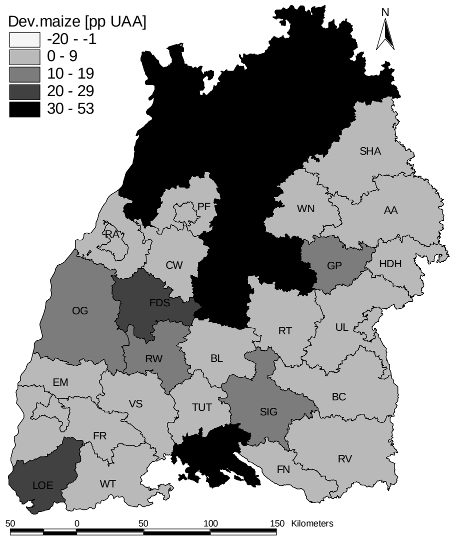
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 c: Change of maize area in EXT compared to CAP2003.



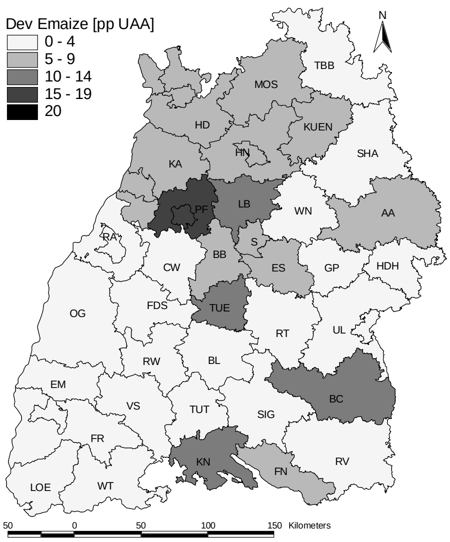
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 d: Change of maize area in INT compared to CAP2003.



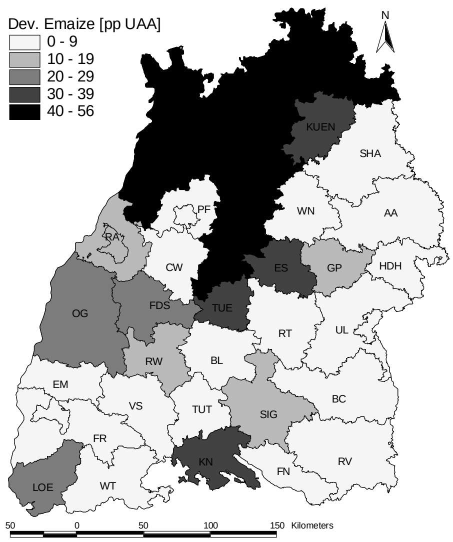
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 e: Change of energy maize area in EXT compared to CAP2003.



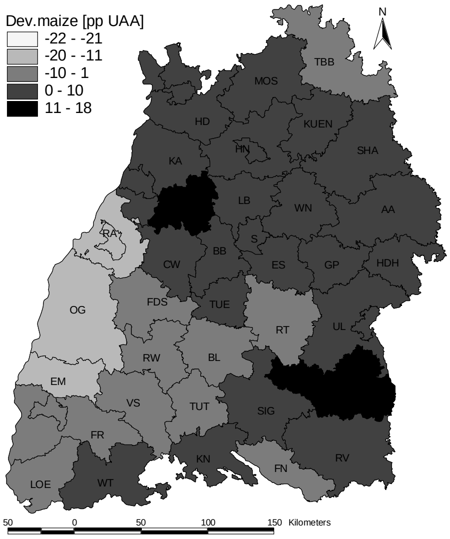
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 f: Change of energy maize area in INT compared to CAP2003.



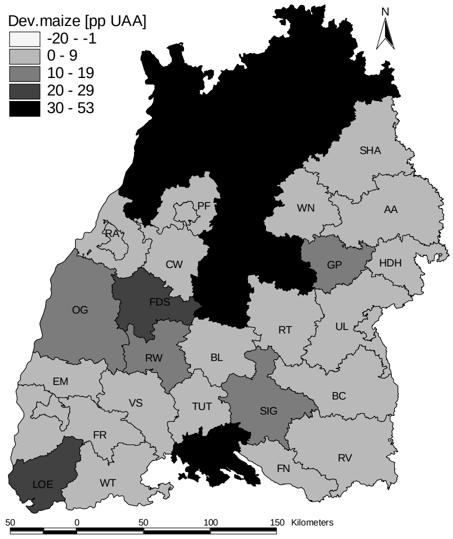
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 g: Change of maize area in EXT compared to CAP2003.



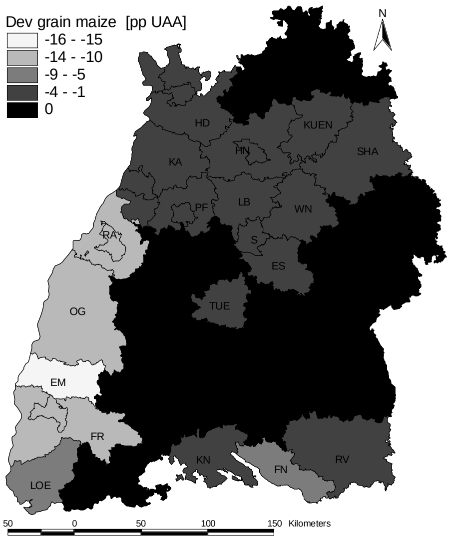
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 h: Change of maize area in INT compared to CAP2003.



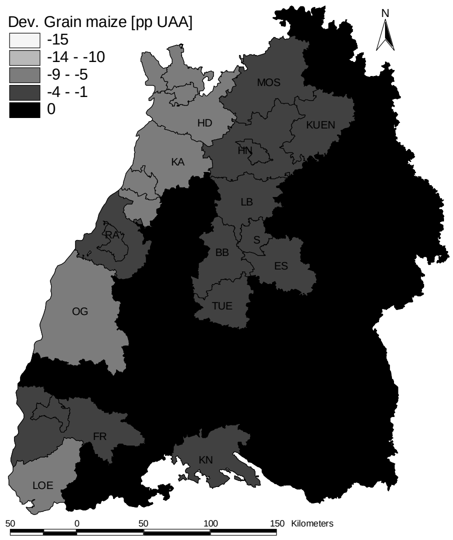
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 i: Change of grain maize area in EXT compared to CAP2003.



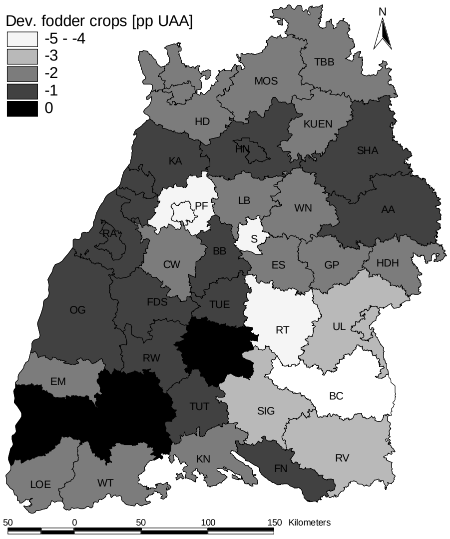
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 j: Change of grain maize area in INT compared to CAP2003.



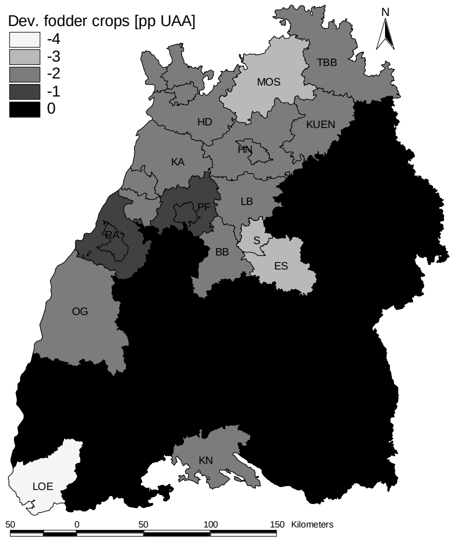
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 k: Change of fodder crop area in EXT compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

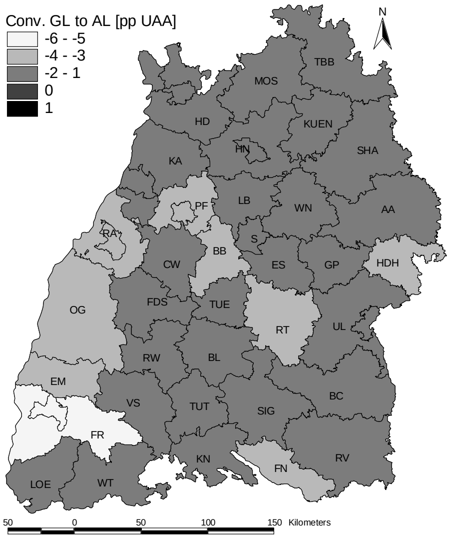
Map 3.6-2 l: Change of fodder crop area in INT compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

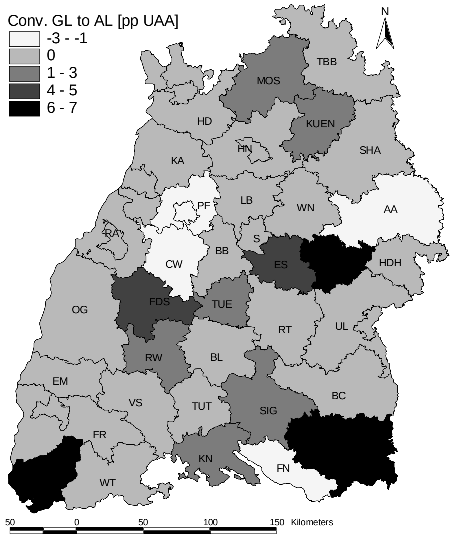
In scenario EXT the conversion of grassland is reduced in all counties. Arable land is converted into grassland, particularly in the western counties (cf. Map 3.6-2 m and o). The increased conversion of grassland results on the one hand from increases in payments for AEM on grassland and on the other hand from the necessity to reduce nitrogen input to the allowed level. In scenario INT the most of the counties show an unchanged or only a small conversion of arable land and grassland (cf. Map 3.6-2 n and p).

Map 3.6-2 m: Change of converted grassland in EXT compared to CAP2003.



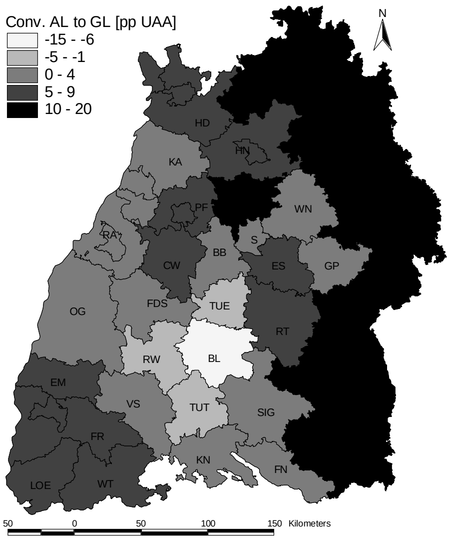
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 n: Change of converted grassland in INT compared to CAP2003.



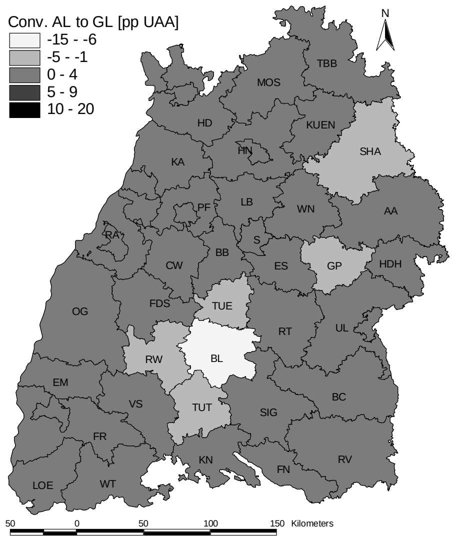
Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 o: Change of converted arable land in EXT compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

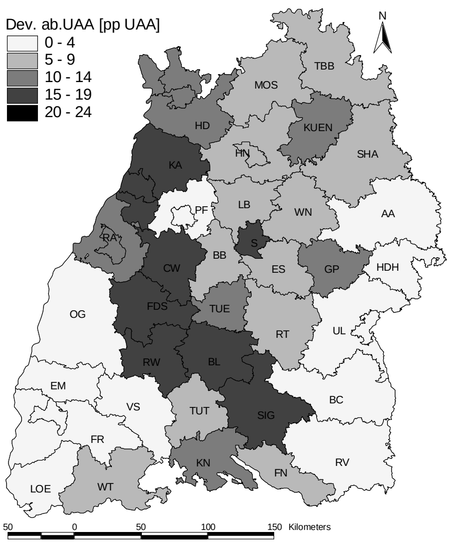
Map 3.6-2 p: Change of converted arable land in INT compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

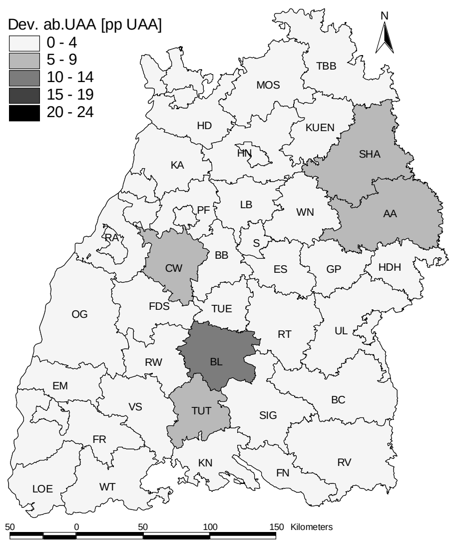
In scenario EXT many counties show abandoned UAA especially in counties with large shares of extensive grassland and in arable crop counties. Counties with high animal density or high shares of special crop area show less abandoned UAA (cf. Map 3.6-2 q). Due to the reduction of nitrogen input the production of intensive crops (e.g. cereals) is reduced. As a result of reduced subsidies UAA cannot be managed profitably and thus falls out of production. Lower productivity of soils provoke that a larger share of arable land falls out of production in extensive countries. In the extensive grassland counties the level of nitrogen input is low in the reference year and the percentage reduction of nitrogen is more sensitive in comparison to counties with a higher reference value of nitrogen input. In scenario INT the input of organic nitrogen is restricted but it allows agricultural production on all the arable land. Only in some extensive grassland and fodder crop counties (e.g. BL, CW, SHA) the decrease in subsidies and the resulting small crop gross margin provoke an abandoning of UAA (cf. Map 3.6-2 r). According to the assumptions of subsidy reduction of scenario SUBred60% increased abandoned UAA could be expected in some more counties or to be more extreme (e.g. MOS, FDS, TUE, SHA, RW cf. Section 3.2-4, Map 3.2-4 g). However, according to the assumptions of the energy crop production scenario EmaizeWW the increased demand from energy crop production for the production factor arable land (cf. Section 3.3.4) compensates for the impact of land abandoning due to reduced subsidies.

Map 3.6-2 q: Change of abandoned UAA in EXT compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

Map 3.6-2 r: Change of abandoned UAA in INT compared to CAP2003.



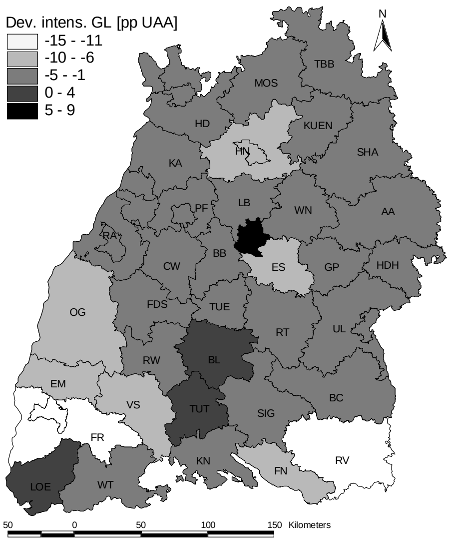
Notes: Unit: pp UAA, basis: REF.

In scenario EXT most of the countries with dominating cash crop as well as fodder crop production counties tend to keep extensive grassland area constant or even increase it.

Grassland counties tend to decrease extensive grassland area, which is converted into abandoned UAA (cf. Map 3.6-3 a, c).

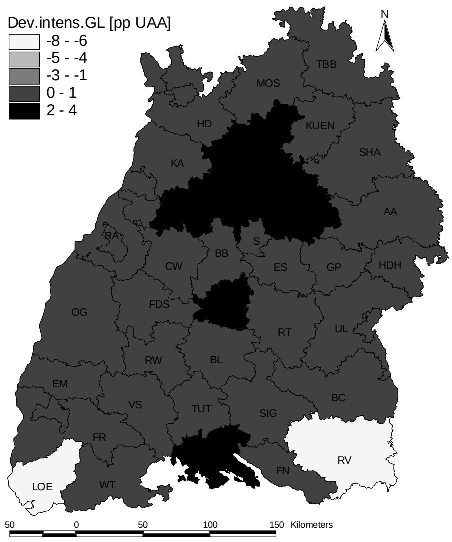
In both scenarios the area of extensive grassland tends to decrease in the counties in Schwabische Alp and Schwarzwald (e.g. BL, FDS). In scenario INT the change in extensive grassland area is less extreme than in scenario EXT (cf. Map 3.6-3 b, d).

Map 3.6-3 a: Change of intensive grassland in EXT compared to CAP2003.



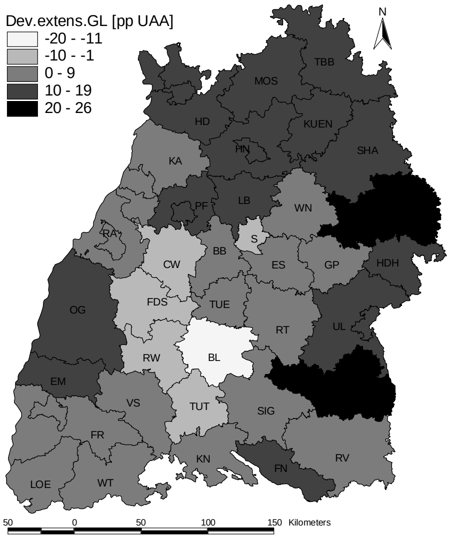
Notes: Unit: pp UAA, basis: REF.

Map 3.6-3 b: Change of intensive grassland in INT compared to CAP2003.



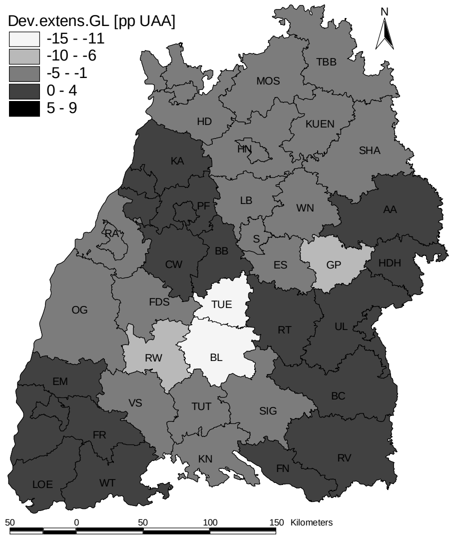
Notes: Unit: pp UAA, basis: REF.

Map 3.6-3 c: Change of extensive grassland in EXT compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

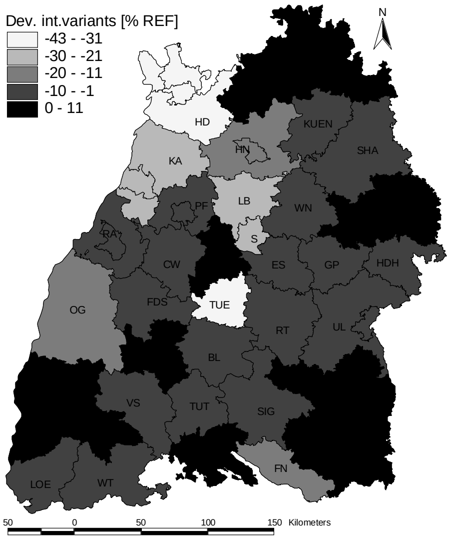
Map 3.6-3 d: Change of extensive grassland in INT compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

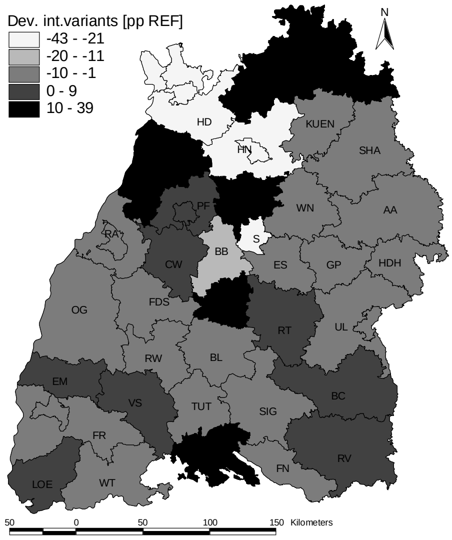
Due to the changes in cash crop production and grassland usage, the development of the area of intensive variants is heterogeneous in both scenarios (cf. Map 3.6-3 e, f). In scenario EXT the intensive crop area tends to decrease in most of the counties. In scenario INT in some counties with dominating arable crop production (e.g. KA, MOS) as well as in some extensive counties (e.g. RW, TUE) intensive crop area increase due to increases in energy maize production (cf. Map 3.6-3 g, h).

Map 3.6-3 e: Change of intensive variant area in EXT compared to CAP2003.



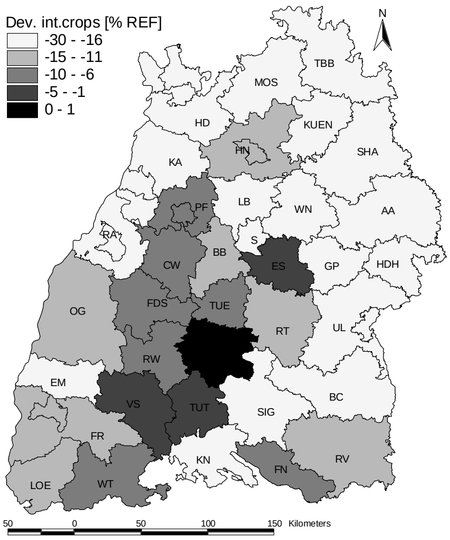
Notes: Unit: pp UAA, basis: REF.

Map 3.6-3 f: Change of intensive variant area in INT compared to CAP2003.



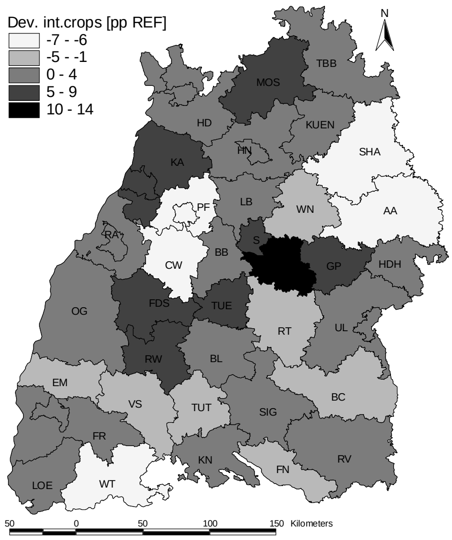
Notes: Unit: pp UAA, basis: REF.

Map 3.6-3 g: Change of intensive crop area in EXT compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

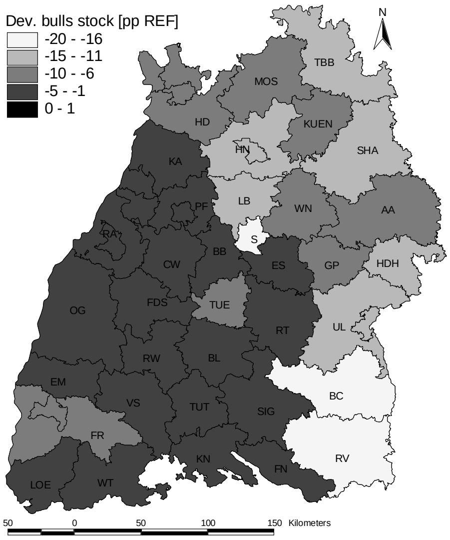
Map 3.6-3 h: Change of intensive crop area in INT compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

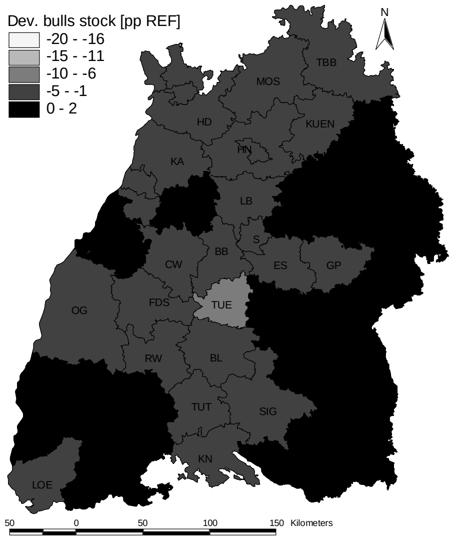
In scenario EXT the production of bulls and pigs is reduced due to the need of reducing total nitrogen input. The total nitrogen input is reduced via decreasing amount of manure as organic fertilizer (cf. Map 3.6-3 i, k). In scenario INT the bulls stock decrease slightly. This effect is not caused due to the nitrogen restriction but due to a reduced fodder production. The energy maize replaces cereals area used for feeding fattening bulls (cf. Map 3.6-3 j, l).

Map 3.6-3 i: Change of bull stock in EXT compared to CAP2003.



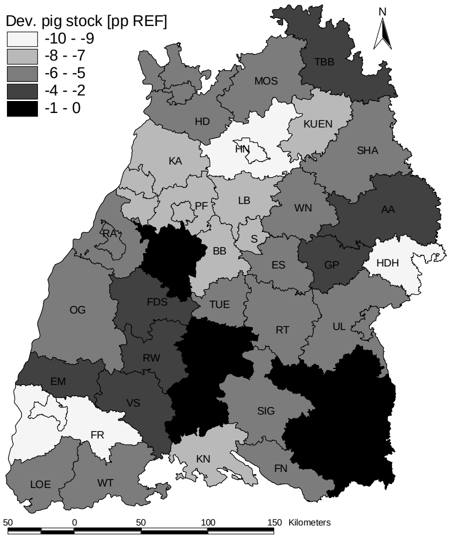
Notes: Unit: %, basis: REF.

Map 3.6-3 j: Change of bull stock in INT compared to CAP2003.



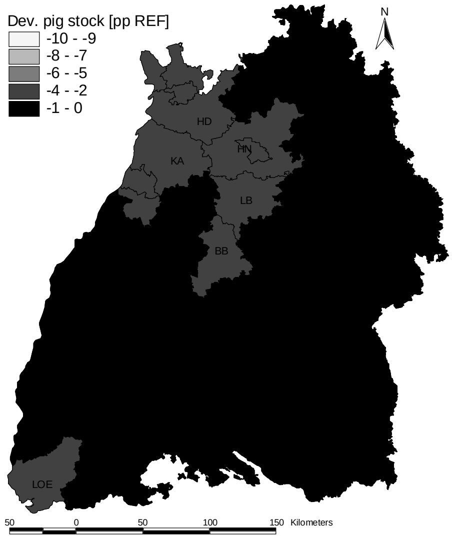
Notes: Unit: %, basis: REF.

Map 3.6-3 k: Change of pig stock in EXT compared to CAP2003.



Notes: Unit: %, basis: REF.

Map 3.6-3 l: Change of pig stock in INT compared to CAP2003.



Notes: Unit: %, basis: REF.

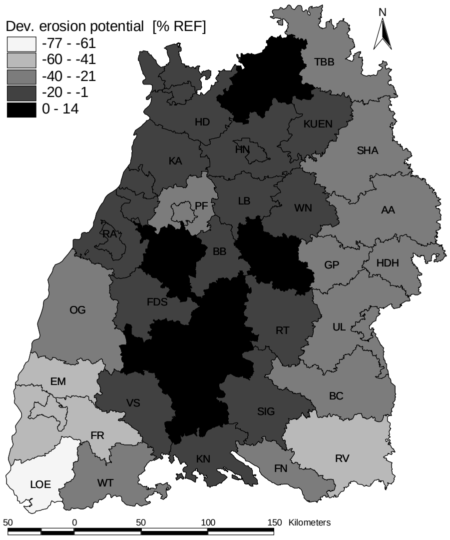
Development of environmental indicator values

In scenario EXT most of the counties show a decrease in erosion potential, which is a result of decreased production intensity. On the contrary in scenario INT the increased production of energy maize provokes a large increase in erosion potential particularly in the northern arable land counties (cf. Map 3.6-4 a, b).

In scenario EXT the total nitrogen input decreases in most of the counties due to the nitrogen restriction. In scenario INT the nitrogen input is increased in extensive counties, where the reference value of total nitrogen is low. The low value brings about a high level of relative changes even though absolute changes in nitrogen amount are small (cf. Maps 3.6-4 c, d).

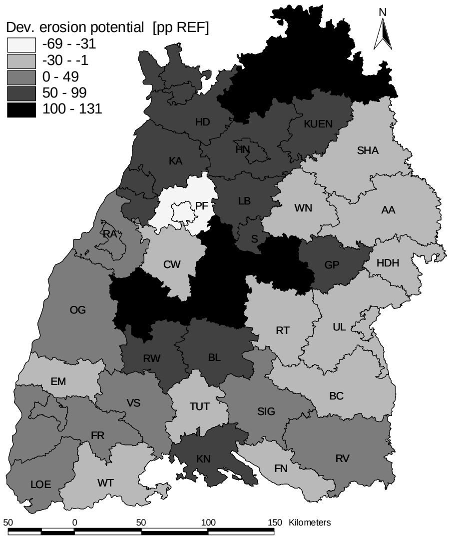
In scenario EXT in the western and eastern counties the potential area for AEM increases due to the increase of extensive grassland area (cf. Map 3.6-4 e). In scenario INT most of the counties reduce the potential AEM area on the one hand due to the reduction of grassland and on the other hand due to the intensification of crop production (cf. Map 3.6-4 f).

Map 3.6-4 a: Change of erosion potential in EXT compared to CAP2003.



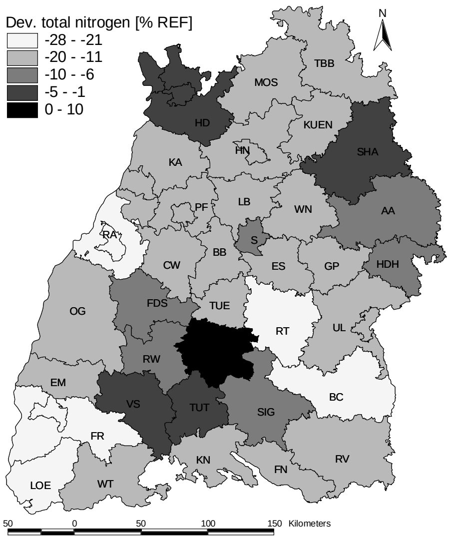
Notes: Unit: %, basis: REF.

Map 3.6-4 b: Change of erosion potential in INT compared to CAP2003.



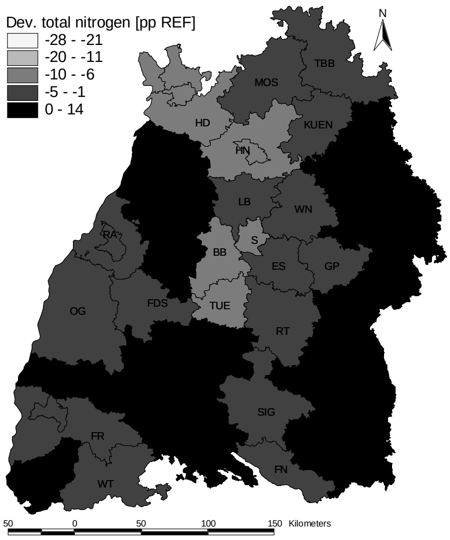
Notes: Unit: %, basis: REF.

Map 3.6-4 c: Change of total nitrogen input in EXT compared to CAP2003.



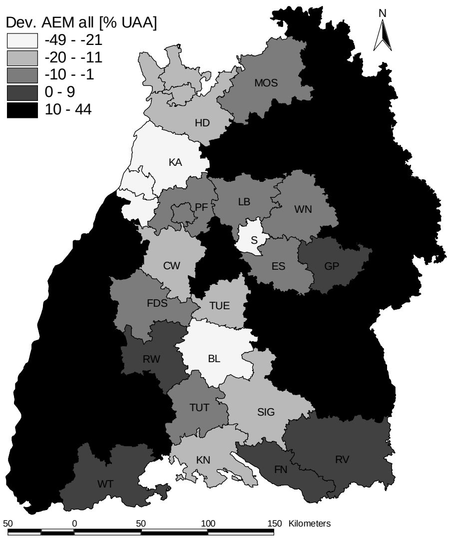
Notes: Unit: %, basis: REF.

Map 3.6-4 d: Change of total nitrogen input in INT compared to CAP2003.



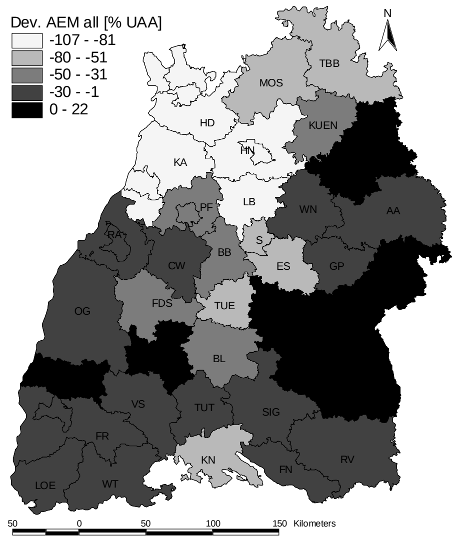
Notes: Unit: %, basis: REF.

Map 3.6-4 e: Change of potential AEM area in EXT compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

Map 3.6-4 f: Change of potential AEM area in INT compared to CAP2003.



Notes: Unit: pp UAA, basis: REF.

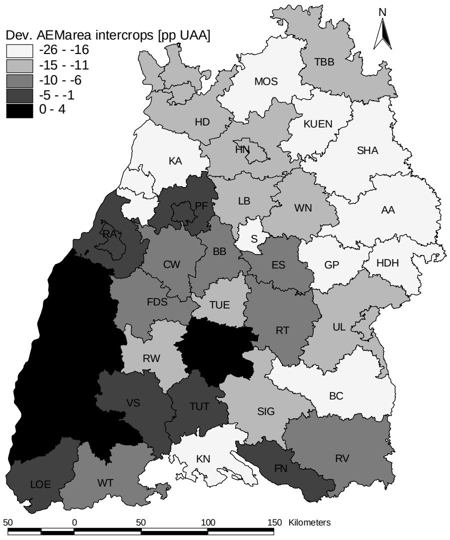
In both scenarios the intercrop area decreases in many counties (cf. Map 3.6-4 g, h). In scenario EXT in the north western counties the decrease can be observed while in the INT scenario the counties of the north eastern part decrease the intercrops area.

In scenario EXT the effect of decreasing intercrop area results from the increases in maize area and from conversion of arable land to either grassland or abandoned UAA on which intercropping is not applied (cf. Map 3.6-2 g, o, q). In scenario INT the energy maize area is expanded and on this area intercropping is not applied (cf. Map 3.6-2 h).

The development of the weighted nitrogen input and the weighted erosion potential is quite different in the two scenarios, due to the nitrogen restriction in the EXT scenario on the one hand, and on the other hand in the INT scenario the increase of intensive production of energy maize.

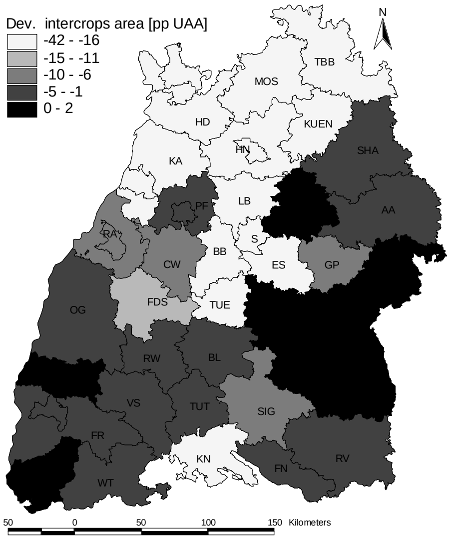
In the INT scenario the weighted nitrogen and erosion potential increases more than in the scenario EXT. Since the differences in intercropping area are significant, also the weighted indicator values show extremely different changes (cf. Maps 3.6-4 i, j and k, l).

Map 3.6-4 g: Change of intercrops area in EXT compared to CAP2003.



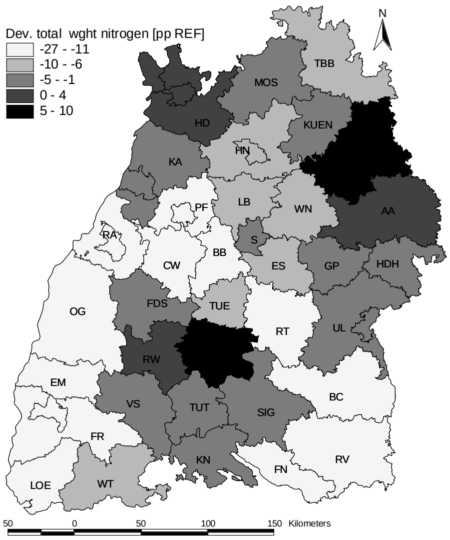
Notes: Unit: pp UAA, basis: REF.

Map 3.6-4 h: Change of intercrops area in INT compared to CAP2003.



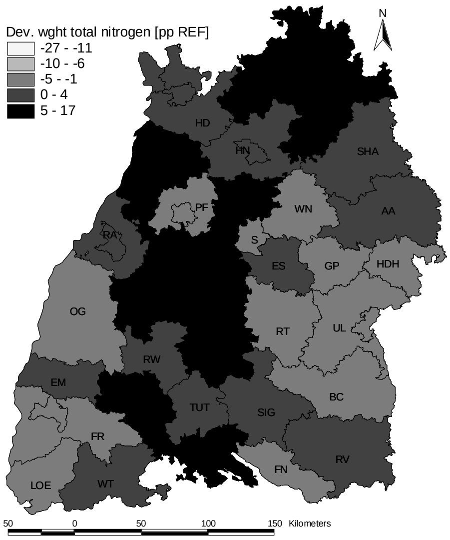
Notes: Unit: pp UAA, basis: REF.

Map 3.6-4 i: Change of total nitrogen input weighted in EXT compared to CAP2003.



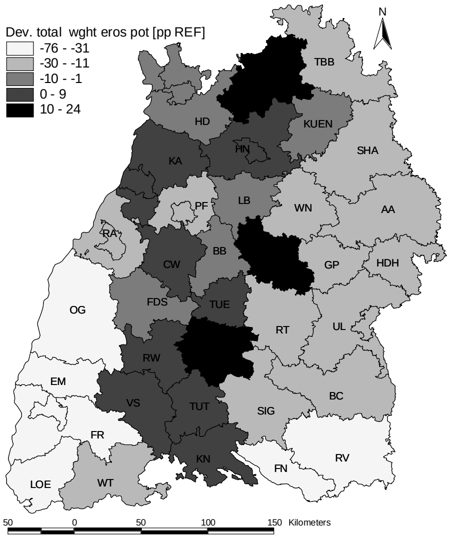
Notes: Unit: %, basis: REF.

Map 3.6-4 j: Change of total nitrogen input weighted in INT compared to CAP2003.



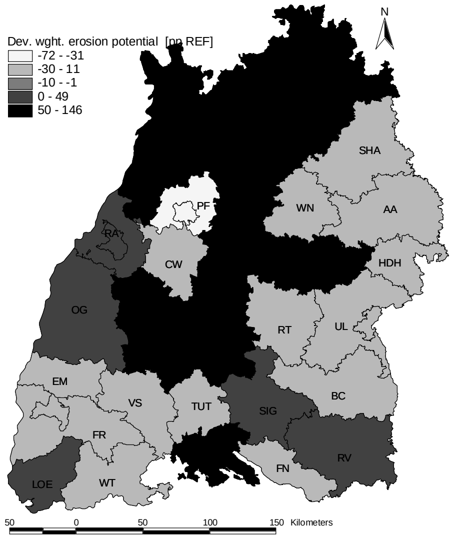
Notes: Unit: %, basis: REF.

Map 3.6-4 k: Change of erosion potential weighted in EXT compared to CAP2003.



Notes: Unit: %, basis: REF.

Map 3.6-4 l: Change of erosion potential weighted in INT compared to CAP2003.



Notes: Unit: %, basis: REF.

3.6.5 Analysis of indicator values according to farm types

In both scenarios the farm types show similar decreases of subsidies which is caused by the similarities in the assumptions regarding the instruments of the scenarios SUBred60% and SUBshift70% (cf. Table 3.6-2 and Section 3.2). In scenario EXT the payments from Pillar 2 increase in all farm types due to the shifting of payments from Pillar 1 to Pillar 2 (cf. Section 3.2). However, due to land abandoning the losses of direct payments are a bit larger in scenario EXT, than in scenario INT. The changes of total gross margins are similar in both scenarios. In scenario INT the losses in AL-CC counties are a little higher than in the scenario EXT because cereals area is replaced by energy maize which is of lower gross margin than cereals (cf. Section 3.3).

In scenario EXT abandoned UAA increases in all farm types, particularly in AL-CC and GL-EG, due to a combined effect of reduced payments from SUBshift70% and the nitrogen restriction from Nred10%. In scenario INT the reduced subsidies (according to scenario SUBred60%) is expected to result in a slight increase of abandoned UAA in AL-CC, AL-FC, GL-FC andin a high increase in GL-EG (cf. Section 3.2.5). However, the increased demand for arable land due to intensive energy crop production reduces or avoids this impact.

The difference in TGM in the other farm types is mainly caused by the impact of the nitrogen restrictions in both scenarios. In scenario EXT the nitrogen input is more reduced than in scenario INT. Thus in scenario EXT the intensity of crop production and animal production is decreased. The extensification of agricultural production results in reduced environmental pressure, indicated by decreases in environmental indicator values and a small increase of potential AEM area.

In scenario INT the developments of indicator values are mainly determined by the production of energy maize. The limitation of organic nitrogen input does not influence production significantly. Cereals area is replaced by maize area and a conversion of grassland into arable land takes place. In most of the farm types the livestock production is kept nearly unchanged. In AL-CC bulls and pig numbers decrease slightly. In GL-FC and GL-EG small shares of abandoned UAA appear. In all farm types the crop production intensity increases but the total nitrogen input tends to decrease slightly. The decrease in nitrogen results from the original model definition of ACRE-Danube for silage maize (cf. Winter 2005). Due to the lack of production data for energy maize production the production data of silage maize have been used to represent activity of energy maize production. The transfer of fertilization data result in a smaller nitrogen demand for energy maize than for the replaced cereals (cf. Section 3.3, Table 3.3-5); a modelling assumption that might be regarded as rather questionable. However the indicator of weighted nitrogen input increases slightly due to reduced area of intercropping. The indicator values erosion potential and weighted erosion potential increase due to the high erosion potential of maize. The potential AEM area decreases in all farm types due to intensification of crop production.

Table 3.6-2: Development of indicator values in EXT and INT.

		EXT						INT					
		AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	All[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	All[g]
SUB[m] volume	[pp]	-63	-62	-63	-72	-73	-64	-62	-66	-61	-70	-72	-64
SUB volume Pillar 1	[pp]	-85	-89	-120	-142	-127	-98	-70	-102	-74	-120	-107	-82
SUB volume Pillar 2	[pp]	30	29	35	21	15	27	-22	1	-11	-1	-9	-8
TGM[n] volume incl. SUB	[pp]	-17	-18	-13	-16	-16	-16	-18	-12	-14	-12	-17	-14
TGM volume excl. SUB	[pp]	-5	-6	-4	-5	4	-5	-8	-2	-2	-2	2	-3
Cereals	[pp][o]	-16	-20	-1	-14	-9	-14	-27	-11	-5	-3	-8	-14
Maize	[pp][o]	3	7	-10	3	1	2	31	15	8	4	10	16
Fodder crops	[pp][o]	-2	-3	-1	-2	-1	-2	-1	-1	-1	0	0	-1
Others[p]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Root crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Oil seeds and legumes	[pp][o]	-1	-2	0	-1	0	-1	-2	-1	0	0	-1	-1
Set-aside area	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Conv. of grassland[q]	[pp][o]	-2	-2	-3	-1	0	-1	0	1	2	2	1	1
Conv. of arable land[r]	[pp][o]	5	10	7	7	0	7	0	0	0	0	-3	-1
Intensive grassland	[pp][o]	-4	-2	3	-1	-2	-2	1	0	-3	-1	0	0
Extensive grassland	[pp][o]	10	14	7	9	-1	10	-2	-2	1	-2	-4	-2
Abandoned UAA[s]	[pp][o]	9	7	1	5	11	6	0	0	0	1	3	1
Dairy cows	[%]	-2	-3	0	-1	0	-3	0	0	0	0	0	0
Bulls	[%]	-8	-10	-4	-9	-2	-9	-2	0	0	0	-1	0
Fattening pigs	[%]	-6	-6	-6	-4	-3	-4	-1	-1	0	0	0	0
Intensive crop area	[pp][o]	-18	-19	-16	-15	-6	-16	2	1	2	-1	3	1
Intensive variant area	[pp][o]	-15	-2	3	-1	-3	-4	-4	0	10	-2	-2	1
Nitrogen total	[%]	-15	-14	-24	-13	-8	-14	-3	-1	-1	0	2	-1
Nitrogen total (weight.)[t]	[%]	-9	-5	-24	-7	-4	-9	3	-1	3	0	4	2
Nitrogen organic	[%]	-7	-6	-4	-5	-6	-6	-1	0	-1	0	-2	-1
Nitrogen demand	[%]	-23	-29	-40	-33	-19	-27	-4	-2	-1	-1	3	-1
Erosion potential	[pp][u]	-15	-13	-59	-30	0	-21	54	17	31	2	43	38
Erosion potential (weight.)[t]	[pp][u]	-9	-4	-59	-24	3	-14	60	15	35	3	42	38
GHG[v] emissions	[%]	-15	-13	-12	-5	-6	-10	-2	1	-1	0	0	-1
Potential AEM area[w]	[pp][o]	5	9	25	4	-5	9	-51	-18	-9	-13	-23	-27

Notes: a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percent share of UAA/percentage points of UAA compared to the share in reference situation. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare/difference in percent. u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. v: Potential in percent of uncovered arable land/difference in percent. w: Green house gas. x: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity.

3.6.6 Analysis of results according to achievement of policy objectives

As expected single counties and the farm types are affected by the modified subsidies with respect to economic, production and environmental indicator values. Differences in changes result from their specific agricultural structure.

Table 3.6-3 presents the impacts of the scenarios EXT and INT with regard to the achievement of policy objectives. In both scenarios and in all farm types the impact is positive on the objective of subsidy reduction for payments from Pillar 1 and negative with regard to stabilization of TGM. In scenario EXT in all farm types the payments from Pillar 2 are influenced negatively due to increasing of payments, while in scenario INT the payments from Pillar 2 in AL-CC, GL-IG and in GL-EG decrease.

In both scenarios and in all farm types the objective of food supply is either not influenced or negatively impacted (e.g. for cereals in GL-IG). In scenario INT the objective of energy crop production is impacted positively. The increased energy crop production impacts the objective of keeping UAA under production positively in AL-CC, AL-FC and GL-EG, by reducing or avoiding the negative impact which is expected due to decreased subsidies. In scenario EXT the environmental objectives are impacted positively in all farm types with respect to nitrogen emissions and extension of potential AEM area. In the INT scenario in all farm types negative impacts on environmental objectives and potential AEM area are caused by the increased production intensity due to increased energy maize production.

Table 3.6-3: Impact on policy objectives in EXT and INT.

		EXT						INT					
		AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	All[g]	AL-CC[a]	AL-FC[b]	GL-IG[c]	GL-FC[d]	GL-EG[e]	All[g]
SUB[m] volume	[pp]	++	++	++	++	++	++	++	++	++	++	++	++
SUB volume Pillar 1	[pp]	++	++	++	++	++	++	++	++	++	++	++	++
SUB volume Pillar 2	[pp]	- -	- -	- -	- -	- -	- -	++	0	++	0	+	+
TGM[n] volume incl. SUB	[pp]	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
TGM volume excl. SUB	[pp]	-	-	0	-	0	-	-	0	0	0	0	0
Cereals	[pp][o]	- -	- -	0	- -	-	- -	--	--	-	0	--	--
Maize	[pp][o]	0	+	+ +	0	0	0	++	++	+	0	++	++
Fodder crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Others[p]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Root crops	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Oil seeds and legumes	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Set-aside area	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Conv. of grassland[q]	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Conv. of arable land[r]	[pp][o]	+	++	+	+	0	+	0	0	0	0	0	0
Intensive grassland	[pp][o]	0	0	0	0	0	0	0	0	0	0	0	0
Extensive grassland	[pp][o]	++	++	+	+	0	++	0	0	0	0	0	0
Abandoned UAA[s]	[pp][o]	-	-	0	-	- -	-	0	0	0	0	0	0
Dairy cows	[%]	0	0	0	0	0	0	0	0	0	0	0	0
Bulls	[%]	-	- -	0	-	0	-	0	0	0	0	0	0
Fattening pigs	[%]	-	-	-	0	0	0	0	0	0	0	0	0
Intensive crop area	[pp][o]	++	++	++	++	+	++	0	0	0	0	0	0
Intensive variant area	[pp][o]	++	0	0	0	0	0	0	0	--	0	0	0
Nitrogen total	[%]	++	++	++	++	+	++	0	0	0	0	0	0
Nitrogen total (weight.)[t]	[%]	+	+	++	+	0	++	0	0	0	0	0	0
Nitrogen organic	[%]	+	+	+	+	+	+	0	0	0	0	0	0
Nitrogen demand	[%]	- -	- -	- -	- -	- -	- -	0	0	0	0	0	0
Erosion potential	[pp][u]	++	++	++	++	0	++	--	--	--	0	--	--
Erosion potential (weight.)[t]	[pp][u]	+	0	++	++	0	++	- -	- -	- -	0	- -	- -
GHG[v] emissions	[%]	++	++	++	+	+	++	0	0	0	0	0	0
Potential AEM area[w]	[pp][o]	+	+	++	0	-	+	--	--	-	--	--	--

Notes: a to d: Clustered counties with high shares of … a: … arable land and cash crops; b: … arable land and fodder crops; c: … intensive grassland; d: … extensive grassland and fodder crops; e: … extensive grassland. f: Average of all counties. g: All counties aggregated. h: Minimum value of all counties. i: 25 percent quartile. j: 50 percent quartile. k: 75 percent quartile. l: Maximum value of all counties. m: Subsidy. n: Total gross margin. o: Percentage points of utilized agricultural area compared to the share in reference situation. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. u: Percentage points difference from reference situation. v: Green house gas. w: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity.
+ small positive impact on objective, ++ medium positive impact on objective, +++ highest positive impact on objective
- small negative impact on objective, - - medium positive impact on objective, - - - highest positive impact on objective, 0: no impact on objective

3.6.7 Scenario discussion

The analysis of the results of the scenarios EXT and INT illustrate the different impacts on objectives when a set of different policy instruments and market assumptions are driving agricultural production simultaneously. As expected the economic objectives are impacted by changes in direct payments from Pillar 1 and 2. An environmental policy which aims at reducing nitrogen input has significant impacts on production intensity and also the demand for energy which is assumed to be driven by energy policy and energy demand.

The analysis identifies developments of the indicators in specific NUTS3 counties as well as for farm types. For policy makers the information derived from these scenarios are useful for orientation as they indicate a need for regional monitoring of agriculture production in cases when regulations are considered to be applied to reduce nitrogen input or the demand for energy production results in intensification of agricultural production.

The scenarios EXT and INT represent story lines with different orientations of the CAP, energy demand and environmental policy. In this modelling exercise scenarios with generally increasing subsidies have not been considered. The scenarios INT and EXT are combined out of the scenarios exercises simulated in the Sections 3.2 to 3.4. The different scenarios are built out of consistent sets of scenario assumptions to represent future CAP, energy crop demand and environmental policies. With respect to the CAP the subsidies are reduced either as simple reduction of Pillar 1 payments or as reduction of Pillar 1 and increase of payments in Pillar 2. Due to different assumptions of market demand for energy crop production the competitiveness between energy maize and food production is either moderate or high. The environmental regulations prescribe limitation of applying organic fertilizer or a reduction of total nitrogen fertilizer.

Concluding remarks

This scenario simulation is an example of application of ACRE as instrument for policy analysis at NUTS3 level also for scenarios which simulate simultaneously more than the implementation of just one change in policy or market assumptions. As presented in the Sections 3.2 to 3.6 the model has its strengths in simulating production at regional level. Shortcomings in the combined scenarios are that it only considers a selection of assumptions, which can be addressed by a production model. Important economic and policy drivers like e.g. structural changes or price developments are not considered. However, it would be interesting to consider them in a more complete storyline. This chapter presents the combined scenarios, assuming two different sets of expected policy and market developments. The combination of assumptions in one scenario (EXT) result in an extensive agricultural production, the other result in an intensive agricultural production (INT). The analysis of the combined scenarios provides information of the regional impacts resulting from a combined set of policy and market developments. This information is particularly useful for policy support on the regional monitoring of agricultural production after introducing new policy measures. Since agricultural policy reforms often consist of a combination of several policy measures and since they are influenced by different market situations, there is need for the analysis of the interactive impacts of policy measures, market situations and regional production patterns.

The combination of policy measures result in the scenarios INT and EXT in regionally different policy impacts than the application of single policy measures as presented in Sections 3.1 to 3.4. The differences can be detected particularly for the impacts on the supply and environmental objectives. Thus, the regional policy analysis can contribute to policy support especially to indicate regional impacts under scenarios which combine several policy measures and market assumptions.

4 Summarizing conclusions and discussion

The agricultural sector of the EU is characterized by regional heterogeneities in agricultural production conditions and structures between and within Member States. Due to the significant regional differences in agricultural production and structure it is important to estimate effects resulting from changes in the CAP at a detailed regional level. In several studies agricultural policy analysis has been done using APM to investigate the impacts of policy scenarios for certain regions. In this study the model ACRE-BW (Agro-eConomic pRoduction model at rEgional level for Baden-Wuerttemberg) has been used to simulate different policy scenarios and to analyze the regional impact of policy measures on agricultural production and income in the study region Baden-Wuerttemberg. The objective of this study is to analyze different agricultural policy scenarios for Baden-Wuerttemberg and at the same time improve and evaluate the suitability of the regional supply model ACRE as a tool for policy analysis and support. In particular the study aims to address the following research questions:

1. What are the regional impacts of different policy measures in the German federal state Baden-Wuerttemberg with respect to economic, production and environmental objectives?
2. How suitable are the simulated policy measures for achieving the policy objectives of the CAP 2003 reform, as well as the objectives of subsidy reduction, promotion of energy crop production, reduction of environmental pollution and promotion of agro-environmental measures?
3. How suitable is the regional supply model ACRE as a tool for policy analysis and policy decision support?

In this chapter summarizing conclusions are drawn with respect to the applied methods and analysed results to answer the research questions. Section 4.1 presents the conclusions on the regional analysis framework and Section 4.2 presents the conclusions on the suitability of ACRE as an APM. Section 4.3 summarizes the conclusions reached from the scenario analysis presented in Sections 3.1 to 3.6. In Section 4.4 the study is evaluated by a strengths and weaknesses analysis.

4.1 Regional analysis framework

Due to regional differences in natural conditions agricultural production in the study region Baden-Wuerttemberg is regionally very heterogeneous. Regional data represent this heterogeneity and are provided at different regional levels. Data on soil quality describe the productivity at NUTS3 level. Data for the geographic and climatic conditions are given for natural regions Vergleichsgebiete (VG). Data for the NUTS3 counties can be derived from the data of the VG by using weightings estimated by the area of the counties' average. Soil quality data and geographic and climate condition data explain the pattern of regional agricultural production (cf. Section 2.2.2).

Production conditions, production patterns and the impact of policy scenarios are analyzed for the complete study region, at regional level (NUTS3) and according to farm types. The analysis for the complete study region provides information about the impact of policy options for the administrative region, the federal state Baden-Wuerttemberg. The administrative region of a federal state is an administrative region for which specific policies are applied (e.g. the agri-environmental program MEKA3). Thus analysis at federal state level provides useful information for policy decisions being relevant at this level. The analysis of NUTS3 regions provides information about the regional impact of policy measures in the different NUTS3 counties. The regional agricultural production in NUTS3 counties varies between extensive counties in mountainous regions dominated by grassland farming and intensive producing counties in valley regions dominated by arable crop and livestock production (cf. Subsection 2.2.1). The analysis of results at NUTS3 county level provides useful information which indicates where applied policies at the regional level have to be closely monitored.

The analysis according to farm types provides information about the impacts of policy measures for NUTS3 counties of similar production patterns. Farm types consist of clusters of NUTS3 counties in which the statistical data on land use are similar (cf. Subsection 2.2.3). The NUTS3 counties are aggregated to five categories of representative farm types, independent of their location in the study region. In this study the farm types are differentiated into two arable land farm types with dominating cash crop production (AL-CC) and fodder crop production (AL-FC), and three grassland farm types with high share of intensive (GL-IG) or extensive grassland area (GL-EG) or high share of fodder crop area (GL-FC). These five farm types represent the regional distribution of the heterogeneous production in the study region Baden-Wuerttemberg in a simplified way (cf. Subsection 2.2.3). Thus, the farm types allow for an analysis of only five farm types which provides a better overview than the analysis of more than 30 different single NUTS3 counties. The impacts on farm types are calculated by the average values of indicators of the NUTS3 counties. The impacts of policies in the single NUTS3 counties can be more extreme than those observed for the farm types. Thus, the farm type analysis provides information on which kind of farm types a certain level of development can be expected while the regional analysis at NUTS3 county level identifies special regional impacts due to policy changes.

4.2 Suitability of ACRE as APM

An APM similar to the ACRE model is RAUMIS. The model RAUMIS has been used in several studies to calculate agricultural and environmental policy scenarios and to analyze policy impacts at regional level. RAUMIS simulates agricultural production at regional NUTS3 level for the whole of Germany and is used by the Johann Heinrich von Thuenen Institut (vTI) within an economic modeling framework as well as as a standalone model. Key characters of RAUMIS are the same as in ACRE. Both models are supply models and they are formulated according to the process analytical approach. Agricultural producers are represented by 'regional farms'. In both models the method of PMP is used to calibrate the non-linear objective functions. Both models are optimization models calculating comparative static for simulation periods of about 10 to 15 years (cf. Subsection 2.3.5).

The major difference between RAUMIS and ACRE is the coverage of the model regions. The RAUMIS model region covers the whole of Germany while ACRE, in the extended version, covers Southern Germany consisting of the federal states Baden-Wuerttemberg and Bavaria. In this study the research questions focus only on the region Baden-Wuerttemberg, and scenarios have been calculated and analyzed only for this study region.

The RAUMIS model is implemented in an economic modeling framework and considers a validation of the database and of the model results by experts, as well as by comparing with other databases and model results. Many studies and collaborations with other institutes show the multifold application of RAUMIS. This model can be regarded as a sophisticated APM for agricultural policy analysis at regional level for Germany (cf. Subsection 2.3.2).

The ACRE model is less sophisticated than the RAUMIS model. This can be partially explained by the different institutional foundation of the model. Development of ACRE is funded only by temporary research funds and retained by temporary staff (PhD students), which makes it difficult to reach the same development status as the RAUMIS model (cf.

Subsection 2.3.5). RAUMIS and ACRE have the same basic model characteristics as they are both regional agricultural supply models. RAUMIS has been used successfully as a policy decision support tool by the German Ministry of Agriculture in several different studies as a standalone model, in interdisciplinary model frameworks as well as in specific economic model frameworks. As ACRE has the same modeling approach as RAUMIS, ACRE can also be regarded as a suitable model to be applied for policy analysis at regional level. Furthermore, as ACRE is particularly tailored to Southern Germany it can be a useful supplement to RAUMIS and has the potential to be applied as a production model in other modeling frameworks in order to provide a detailed analysis at the regional level of Southern Germany.

The PMP approach in ACRE is based on Roehm and Dabbert (2003) and allows the simulation of different production intensities. The regional information about production intensities and the formulation of production processes are devised according to regional farm management (Winter 2005). Therefore, ACRE allows the simulation of agricultural production which specifically considers the regional farming situation in the study region. Thus, ACRE is an appropriate model to specifically address agri-environmental policy scenarios for the region of Southern Germany, where for example agricultural production in less favoured areas (LFA) is of considerable importance.

The validation of ACRE via ex-post analysis and via an analysis of the aggregation error demonstrated a good forecasting quality as well as an acceptable error of aggregation. Thus, due also to its validity, ACRE can be regarded as a suitable model for agri-policy analysis in the study region Baden-Wuerttemberg (cf. Subsection 2.3.3 and 2.3.4).

4.3 Conclusion from the scenario results

In the analysis of the policy scenarios' results, changes in indicator values are used to derive the impact of policy instruments on farm types, model region and policy objectives. The impact of policy instruments are expected to reflect the objective relations as presented by Table 2.1-1. The changes in indicator values in the baseline scenario CAP2003 are compared to the reference year (REF). All the other simulated scenarios are then compared to the baseline scenario CAP2003.

Table 2.1-1 (repeated): Relations of investigated objectives.

	Economic objectives		Supply objectives			Environmental objectives		
	Subsidy reduction	Income stability	Food security	Energy crop production	Retaining of UAA	Reduction of production intensity	Reduction of environ-mental pollution	Agri-environ-mental programs
Subsidy reduction		-	-	-	-	- / +	- / +	+ / -
Income stability			+	+	+	- / +	- / +	- / +
Food security				-	+	-	-	-
Energy crop production					+	-	-	-
Retaining of UAA						- / +	- / +	- / +
Reduction of production intensity							+	+
Reduction of environ-mental pollution								+
Agri-environ-mental programs								
Legend: + complementary objectives, - competitive, - / + potentially both complementary or competitive								

4.3.1 The CAP2003 scenario

The assumptions of the scenario CAP2003 are based on the policy instruments introduced by the CAP 2003 reform. The strongest impact in the scenario CAP2003 results from the decoupled direct payments from Pillar 1, which are harmonized for all UAA and significantly increased for grassland. Table 4.3-1 presents the impacts of the CAP2003 for the farm types and for the model region.

In BW the subsidy volume increases and thus implies on the one hand a negative impact on the objective of subsidy reduction but on the other hand a positive impact on farm income stability. The farm types GL-GE and GL-FC show a strong increase in subsidy volume and hence a positive development in income stability (e.g. NUTS3 counties RV, BL). In AL-CC and AL-FC the increase in subsidy volume is smaller than for the other farm types but increased income still indicates a positive development for income stability (e.g. NUTS3 counties SHA, HDH). The regional distribution of average subsidies and average income is heterogeneous among the NUTS3 counties. Thus, a payment scheme which would be applied regionally and more specified to the production conditions in the NUTS3 regions might result in a more efficient and more equalized income distribution.

In BW food production develops positively with respect to cereal production and negatively with respect to fattening bulls and pig production. In the arable farm types AL-CC and AL-FC (e.g. counties SHA, HDH) the cereal production area increases and the numbers of bulls and pigs decrease, which means a shift from meat to cereal production. In grassland farm types GL-GI, GL-GE and GL-FC production of pigs decreases without an expansion of the cereals area (e.g. NUTS3 counties FR, RV, BL). Thus, for grassland farm types food crop production is not influenced significantly. The impact of CAP2003 on pig production is neutral to slightly positive in arable farm types and slightly negative in grassland farm types. In all farm types the crop yields are supposed to increase, UAA does not fall abandoned and intensive crop area is extended.

In BW the impact on all three environmental sub-objectives (reduction of production intensity, reduction of environmental pollution and increase of AEM area) is negative, as well as for all farm types except in GL-FC and GL-EG (e.g. counties RV, BL). This is because the increased production intensity results in increased environmental pressure and in a reduced AEM area. A regional monitoring of agricultural production might be needed to counteract and avoid the increased environmental pressure in certain regions.

The analysis of the results calculated for the CAP2003 scenario reflect the relation of objectives presented in Table 2.1-1 and suggest that the simulated policy instruments of the CAP 2003 reform do not achieve all the stated objectives of the CAP. Compared to the status quo in REF, the objectives of reduction of subsidies and of reduction of environmental pressure are not fulfilled. However, the objectives of income stability and food security are reached. Thus, the instruments of subsidy payment should be modified in order to be more targeted and efficient in reaching a stable income without strong regional heterogeneity and to comply with environmental objectives. Food production and environmental issues should be monitored regionally in order to ensure agricultural production without increased environmental pressure.

Table 4.3-1: Impacts on policy objectives in CAP2003.

		Economic objectives		Supply objectives			Environmental objectives		
		Subsidy reduction	Income stability	Food security	Energy crop pro-duction	Retai-ning of UAA	Reduction of pro-duction intensity	Reduction of environ-mental pollution	Agri-eviron-mental programs
CAP2003	BW	- -	+	0/+	no data	0	-	- -	- -
	AL-CC	-	++	0/+	no data	0	-	- -	-
	AL-FC	-	+	0/+	no data	0	-	-	- -
	GL-IG	- -	++	-	no data	0	-	- -	-
	GL-FC	- - -	++	-	no data	0	-	-	0
	GL-EG	- - -	+++	-	no data	0	0	0	-

4.3.2 The subsidy reduction scenarios

The policy instruments simulated in the scenarios SUBred60% and SUBshift70% aim to reduce subsidy volume while keeping as a scenario condition the total income level of the model region equal to the reference situation (REF). While SUBred60% implies only the reduction of subsidies by 60% of Pillar 1 payments the scenario SUBshift70% implies the shifting of 70% of payments from Pillar 1 to Pillar 2 and promotes the application of AEM.

Table 4.3-2 presents the impacts of the scenarios SUBred60% and SUBshift70% for the farm types and for the model region which reflect partially the relation of objectives presented in Table 2.1-1. In comparison to the baseline scenario CAP2003 in all farm types the objective of subsidy reduction is positively impacted while income stability is impacted negatively by the decreased subsidy volume as expected. The heterogeneity in the distribution of average subsidies and average income is reduced. In the extensive grassland farm types GL-EG (e.g. counties TUE, BL, RW) the decreased direct payments result in the abandonment of UAA in both scenarios, i.e. in SUBshift70% also the increase of payments from Pillar 2 does not avoid land abandonment.

In SUBred60% impacts on the supply and environmental objectives are not shown in BW as a whole, but appear in the farm types. In farm types GL-EG the intensive crop area decreases. However, environmental pressure increases because of increased nitrogen input intensity. The potential AEM area decreases in BW and in the farm types AL-CC, GL-IG and GL-EG (e.g. in NUTS3 counties TBB, FR, BL) and only increases in AL-FC (e.g. in the county UL).

In SUBshift70% in BW as a whole the objectives of crop or animal production and environmental objectives are not influenced, even though the potential AEM area is impacted negatively despite the increase of payments from Pillar 2. In AL-CC and GL-EG AEM is reduced (e.g. counties TBB, BL). In farm type GL-EG (e.g. county BL) abandonment of UAA and a decrease in potential AEM appears. In this farm type the increased payments for the AEM of intensive and extensive grassland and for intercropping are not sufficient to keep UAA in production. Thus the two scenarios show that the modified direct payments address the objectives of subsidy reduction and income stabilization: which result from the scenario assumptions of modified direct payments in combination with the increases in producer prices and crop yields. However they do not prevent the abandonment of UAA in extensive regions. Increased payments from Pillar 2 are not suitable in this way to extend the AEM area. To work effectively and achieve the stated policy goals the direct payments need to be reduced.

At the same time they need to be more tailored to the specific regional conditions in order to address the subsidy reduction under consideration of the supply and environmental objectives.

Table 4.3-2: Impacts on policy objectives in SUBred60% and SUBshift70.

		Economic objectives		Supply objectives			Environmental objectives		
		Subsidy reduction	Income stability	Food security	Energy crop pro-duction	Retai-ning of UAA	Reduction of pro-duction intensity	Reduction of environ-mental pollution	Agri-eviron-mental programs
SUBred60%	BW	++	- -	0	no data	0	0	0	0
	AL-CC	++	- -	0	no data	0	0	0	- -
	AL-FC	++	- -	0	no data	0	0	0	+
	GL-IG	++	- -	0	no data	0	0	0	0
	GL-FC	++	- -	0	no data	0	0	0	- -
	GL-EG	++	- -	0	no data	0	+	-	- -
SUBshift70%	BW	++	- -	0	no data	-	0	0	-
	AL-CC	++	- -	0	no data	0	0	0	- -
	AL-FC	++	- -	0	no data	0	+	0	0
	GL-IG	++	- -	0	no data	0	0	0	0
	GL-FC	++	- -	0	no data	0	0	0	0
	GL-EG	++	- -	0	no data	-	0	0	- -

4.3.3 The energy crop scenarios

The underlying assumption of the energy crop scenarios EmaizeSM and EmaizeWW is a different competitiveness between food production and energy maize production which result from different demands for and promotion of energy maize production. Thus, it is assumed that the difference in competitiveness between energy maize and food production is driven by differences in energy demand, energy policy and in technological progress. These three drivers for the different competitiveness are not simulated in ACRE directly but implied in the different simulation of energy maize in both scenarios EmaizeSM and EmaizeWW.

Table 4.3-3 presents the impacts of the scenarios EmaizeWW and EmaizeSM for the farm types and for the model region which reflect partially the relation of objectives presented in Table 2.1-1. In both scenarios the economic objectives of subsidy reduction and income stabilization are not impacted. In the scenario EmaizeSM in BW as a whole the objective of food supply is negatively impacted, while the objective of energy supply is impacted positively. Energy maize production partially replaces cereal production, and particularly for farm types AL-CC and AL-FC (e.g. NUTS3 counties KUEN, BC). In BW and in all farm types the environmental objectives are negatively impacted by increased erosion potential. In farm types AL-CC, GL-FC and GL-EC (e.g. NUTS3 counties PF, WM, BL) the potential AEM area (e.g. intercrop area) decreases while the area of energy maize is expected to be increased.

In the scenario EmaizeWW the impacts are the same as in the scenario EmaizeSM. However, the impacts are more extreme due to the larger extension of the energy maize area resulting from the higher competitiveness of energy maize production.

Table 4.3-3: Impacts on policy objectives in EmaizeSM and EmaizeWW.

		Economic objectives		Supply objectives			Environmental objectives		
		Subsidy reduction	Income stability	Food security	Energy crop pro-duction	Retai-ning of UAA	Reduction of pro-duction intensity	Reduction of environ-mental pollution	Agri-eviron-mental programs
EmaizeSM	BW	0	0	-	+	0	0	- -	- -
	AL-CC	0	0	- -	+	0	0	- -	- -
	AL-FC	0	0	- -	+	0	0	- -	- -
	GL-IG	0	0	0	+	0	-	- -	0
	GL-FC	0	0	0	0	0	0	- -	-
	GL-EG	0	0	0	0	0	-	- -	0
EmaizeWW	BW	0	0	- -	++	0	0	- -	- -
	AL-CC	0	0	- -	++	0	0	- -	- -
	AL-FC	0	0	- -	++	0	-	- -	- -
	GL-IG	0	0	-	+	0	-	-	0
	GL-FC	0	0	-	++	0	-	- -	- -
	GL-EG	0	0	-	+	0	-	- -	-

From the analysis of the results it can be concluded that an expected increase in demand for energy maize production would require policy instruments to monitor regionally the extension of energy maize production in order to avoid regionally decreased food production and increased environmental pressure. The need for monitoring would depend on the competitiveness between energy crop production and agricultural food production.

4.3.4 The nitrogen reduction scenario

In both nitrogen reduction scenarios it is assumed that the input of nitrogen is limited in agricultural production. Scenario Nred10% is derived from the OSPAR convention and the nitrogen input from agricultural production is limited to 90% of the total nitrogen input in REF. The scenario Nred170kg is derived from the Water Framework Directive (WFD) and the input of organic nitrogen is limited to a maximum of nitrogen applied of 170 kg organic N per ha UAA (cf. Section 3.4).

The Nred170kg has not been calculated because the level of average organic nitrogen intensity in the baseline scenario CAP2003 is already smaller than ther restriction in Nred170kg requests. Hence, even though such a restriction could be binding for some individual farms at farm level, it is not binding at regional or farm type level and thus would not result in any impact when analyzed with ACRE.

Table 4.3-4 presents the impacts of the scenario Nred10% in the farm types and in the model region which reflect partially the relation of objectives presented in Table 2.1-1. In the entire study region BW the objective of subsidy reduction is impacted positively while income stabilization is impacted negatively. This development is particularly shown in the farm types AL-CC and AL-FC (e.g. counties SHA, SIG). Farm type GL-FC (e.g. county RT) only shows a negative impact on income stabilization but no impact on subsidy volume. The developments in subsidy volume and in income result from a reduction in production and from abandonment of UAA due to the limitation of nitrogen input. In BW and in all farm types food production is impacted negatively. In AL-CC and AL-FC (e.g. counties LB and MOS) cereal and livestock production in particular are reduced. In BW UAA falls abandoned in the farm types AL-CC and AL-FC (e.g. counties KUEN and SIG). As expected in BW and in all farm types environmental pressure is reduced by reductions in production intensity as well as reductions in pollution by nitrogen and soil erosion potential. In the grassland farm types GL-IG, GL-FC and GL-EG the potential AEM area is extended (e.g. in the counties EM, WN and RT).

The nitrogen reduction scenario Nred10% illustrates that the reduction of environmental pollution by a limitation of nitrogen input results in negative impacts on income and supply objectives for the entire model region. The impacts on the farm types are regionally different. Thus, policy measures to reduce the input of nitrogen should be monitored regionally with respect to the regional production conditions and might have to be accompanied by specific direct payments in order to comply with the objective of farm income stabilization.

Table 4.3-4: Impacts on policy objectives in Nred10%.

		Economic objectives		Supply objectives			Environmental objectives		
		Subsidy reduction	**Income stability**	**Food security**	**Energy crop pro-duction**	**Retai-ning of UAA**	**Reduction of pro-duction intensity**	**Reduction of environ-mental pollution**	**Agri-eviron-mental programs**
Nred10%	BW	+	-	- -	no data	-	++	+++	0
	AL-CC	+	-	- -	no data	-	++	+++	0
	AL-FC	++	-	- -	no data	- -	++	+++	0
	GL-IG	0	0	- -	no data	0	++	+++	++
	GL-FC	0	-	-	no data	0	++	+++	++
	GL-EG	0	0	-	no data	0	++	+++	+

4.3.5 The mandatory AEM scenario

In the scenario of mandatory AEM it is simulated that as many AEM as possible are applied. It is assumed that either it is mandatory to apply the AEM or that all producers voluntarily aim to apply AEM in order to ensure a more environmentally friendly production.

Table 4.3-5 presents the impacts of mandatory AEM for the farm types and for the model region which reflect partially the relation of objectives presented in Table 2.1-1. As expected, the area of potential AEM increases, however the scenario does not show the impact of subsidy reduction and income stabilization on the economic objectives, for BW or the farm types. In BW the scenario has a negative impact on food production and a positive impact on environmental objectives. However, the impacts on food production, on reduction of production intensity and on reduction of environmental pollution are different for the farm types. The farm types AL-FC and GL-FC (e.g. counties BC and AA) show a negative impact on food production and a positive impact on environmental objectives. For the farm types AL-CC and GL-EG food supply is not influenced (e.g. counties PF and BL) but for farm type AL-CC production intensity is increased (e.g. in the county PF). For farm type GL-IG (e.g. county LOE) food supply and environmental objectives are both influenced positively.

The scenario of mandatory AEM shows that the implementation of mandatory AEM achieves its main objective in increasing area under AEM, but results, especially with respect to food supply, in regional different impacts in the farm types and NUTS3 counties. Thus, policies steering the application of AEM need close monitoring at regional level; in order to not neglect the achievement of other policy objectives.

Table 4.3-5: Impacts on policy objectives in mandatory AEM scenario.

		Economic objectives		Supply objectives			Environmental objectives		
		Subsidy reduction	**Income stability**	**Food security**	**Energy crop pro-duction**	**Retai-ning of UAA**	**Reduction of pro-duction intensity**	**Reduction of environ-mental pollution**	**Agri-eviron-mental programs**
MandAEM	BW	0	0	- -	no data	0	++	++	++
	AL-CC	0	0	0	no data	0	-	++	++
	AL-FC	0	0	- -	no data	0	++	++	++
	GL-IG	0	0	+	no data	0	+	++	++
	GL-FC	0	0	- -	no data	0	+	++	++
	GL-EG	0	0	0	no data	0	0	0	++

4.3.6 The combined scenarios

The combined scenarios are based on two different assumptions of policy and market development which provoke an extensive agricultural production scenario (EXT) and an intensive agricultural production scenario (INT). Scenario EXT assumes a subsidy policy similar to in the scenario SUBshift70%, the competitiveness of energy crop production as in the scenario EmaizeSM and an environmental policy like that simulated in the scenario Nred90%. Scenario INT assumes the policies applied in the scenarios SUBred60% and EmaizeWW and considers the restriction of the scenario Nred170kg.

Table 4.3-6 presents the impacts of the scenarios EXT and INT for the farm types and for the model region. In both scenarios the assumptions of SUBred60% and SUBshift70% respectively result in positive impacts on subsidy reduction and negative impacts on income stabilization. This development appears for the study region as a whole as well as for all farm types and is extremely pronounced in some counties (e.g. RV, BL, TU, KA).

In both scenarios food production in BW is impacted negatively. In scenario EXT the reduction of food supply in BW and for all farm types is partially caused by increases in energy crop production. However, the strongest impact on the reduction of food supply is provoked by reduction of nitrogen input, which results in a reduction of production intensity and of pollution and in an increase in abandoned UAA and potential AEM area. The effects for farm types are slightly different. Only for farm type AL-FC (e.g. in the county BC) does energy crop production increase, and only for farm type GL-IG does UAA not fall abandoned (e.g. in the county FR). With respect to the environmental objectives, farm type GL-IG (e.g. in the county LOE) is impacted most positively by the reduction of erosion potential due to reduction in maize area; this is because energy maize production is rather increased in intensive cropping regions.

In scenario INT the reduction in food production in BW is driven by increases in energy crop production on the one hand and on the other hand by an increase in abandoned land due to the subsidy reduction. The subsidy reduction is expected to result in a negative impact on retaining of UAA for farm types in AL-CC, AL-FC and GL-EG (e.g. TUE, SHA, MOS, FDS, RW). On the contrary, the increased energy crop production results in higher demand for arable land and this higher land demand compensates or reduces the negative impact from land abandonment. Energy crop production increases for all farm types except GL-FC (e.g. county AA) and results in GL-FC therefore also producing less negative impacts for the environment, while for all other farm types environmental pollution increases due to an increase in erosion potential. For all farm types the increased areas of energy maize result in decreases in potential AEM.

The combined scenario shows that the impacts of the implementation of combined policy measures and market developments (i.e. energy crop demand) on policy objectives are regionally more diverse than if only the implementation of one policy measure is assumed (as was done for the other policy scenarios in this study). This observation holds especially with regard to impacts on environmental objectives. In order to support policy decision making it is therefore even more important not only to analyze the impacts on the aggregate of the complete study region BW, but also according to farm types and at NUTS3 level. The regional impact analysis provides information for appropriate policy measures in order to trigger regionally positive impacts and to avoid regionally negative impacts on policy objectives.

Table 4.3-6: Impacts on policy objectives in EXT and INT.

		Economic objectives		Supply objectives			Environmental objectives		
		Subsidy reduction	**Income stability**	**Food security**	**Energy crop pro-duction**	**Retai-ning of UAA**	**Reduction of pro-duction intensity**	**Reduction of environ-mental pollution**	**Agri-evironmental programs**
EXT	BW	++	- -	- -	0	-	++	++	+
	AL-CC	++	- -	- -	0	-	++	++	+
	AL-FC	++	- -	- -	+	-	++	++	+
	GL-IG	++	- -	0	0	0	+++	++	++
	GL-FC	++	- -	- -	0	-	++	+	0
	GL-EG	++	- -	-	0	- -	+	+	-
INT	BW	++	- -	- -	++	0	0	- -	- -
	AL-CC	++	- -	- -	++	0	0	- -	- -
	AL-FC	++	- -	- -	++	0	0	- -	- -
	GL-IG	++	- -	-	+	0	0	- -	-
	GL-FC	++	- -	- -	0	0	0	0	- -
	GL-EG	++	- -	- -	++	0	0	- -	- -

4.3.7 Conclusions from the comparison of the scenarios

In this study the application of several policy instruments, aiming to achieve different policy objectives, are simulated in various policy scenarios. The different policy instruments are modelled by different modelling techniques. The policy scenarios in Sections 3.2 to 3.5 simulate the application of only separately applied policy instruments while in Section 3.6 the single instruments are combined in order to investigate the impact of their interaction. The baseline scenario introduced in Section 3.1 models a combination of policy instruments as well.

Comparison of the modeling techniques in the scenarios

The Scenario CAP2003 is modeled by the use of different modeling techniques in combination. The decoupled direct payments from Pillar 1 and the changed payments from Pillar 2 are modeled by the modeling technique 'variation of parameter values' (i.e. the parameters direct payments from Pillars 1 and 2). Also the market situation in the target year 2015 is modeled by the 'variation of the parameter values', i.e. in this case the producer prices. The SMR of retaining permanent grassland is implemented as a 'model constraint' (cf.

Subsection 3.1.2). The modeling techniques are explained in more detail in the single policy scenarios calculated in Sections 3.2 to 3.6.

In the subsidy reduction scenarios (SUBred60% and SUBshift70%) the reduced and modified direct payments are simulated by a 'variation of parameter values'. The 'variation of parameter values' shifts the gross margin functions so that the model finds a new optimum under the modified policy instruments. The modeling technique of 'variation of parameter values' adequately represents the change to an existing policy (i.e. changes in the amount of direct payments) according to which farmers optimize their new production portfolio.

In the energy crop scenarios (EmaizeWW and EmaizeSM) an 'additional crop production activity' is used to introduce and simulate energy crop production. The 'additional crop production activity' lets the function complex of the model find an optimum which additionally considers the new calibrated activity of energy crop production. This implies that, for the newly calculated crop production activity, limited production factor resources are allocated to energy crop production and that they are no longer available for the other production activities. The modeling technique 'additional crop production activity' represents the situation whereby policy promotes a new production alternative for which farmers can voluntarily opt for and can be regarded as an adequate method of model the production of energy crops.

A 'calibration with different shadow prices' reflects different competition of the energy crop production in comparison with the other production activities. The two different shadow prices of silage maize and winter wheat are used to calibrate the 'additional crop production activity'. This modeling technique results in different slopes of the gross margin functions which means a steeper slope for the activity calibrated with higher shadow prices (c.f. Section 3.2.7). The modeling technique of 'calibration with different shadow prices' represents different competition of activities. The different demand for energy crop supply is driven by energy policies and technological progress in energy techniques. These drivers are not represented in ACRE but the 'calibration with different shadow prices' can be regarded as an appropriate solution to represent different competitions between energy crop and food production and thus represent the different market situation of energy crops. As an alternative to the 'calibration with different shadow prices', different competition of energy crops could be simulated by varied prices, which corresponds to the modeling technique 'variation of parameter values'. In the nitrogen reduction scenarios and in the scenarios of mandatory AEM the modeling technique 'model constraints' is used. With this modeling technique the model finds the optimum under the condition that the extension of certain activities are either lower than an upper benchmark (e.g. restriction according to OSPAR convention in Nred90% scenario) (cf. Subsection 3.4.3); greater than a lower benchmark (e.g. AEM NE-2 'greening of arable area in autumn') or restricted by upper and lower benchmarks (e.g. AEM NB-2 'cattle density is between 0.3 and 1.4 LU per hectares') (cf. Subsection 3.5.3). The 'model constraints' simulate regulations and compulsory requirements which drive farmers to observe a maximum nitrogen input or to apply as many AEM as possible. In comparison to the other modeling techniques the 'model constraints' have the strongest impact (i.e. the most restrictive) on the optimum and thus can represent the assumptions of regulations and obligatory measures appropriately. Table 4.3-7 gives an overview of the different modeling techniques used in the policy scenarios.

Table 4.3-7: Overview of modeling techniques used in the scenarios.

Scenario	Modeling technique/Scenarios	Representing the instrument	Scenario assumption
CAP2003	'variation of parameter values'	changed payments	CAP decoupled unified payments from Pillar 1,
	'variation of parameter values'	changed payments	CAP changes payments from Pillar 2
	'variation of parameter values'	changed producer prices	changed market situation
	'model constraints'	law, mandatory measures	SMR to retain permanent grassland
SUBred60%, SUBshift70%	'variation of parameter values'	changed payments	CAP reduces payments
EmaizeWW, EmaizeSM	'additional crop production activity'	promotion of production alternative	CAP
	'calibration with different shadow prices'	different competitiveness between energy crop production and other agricultural products	different demand for energy crops
Nred170kg, Nred10%	'model constraints'	law, mandatory measures	laws to reduce nitrogen input are applied
Mandatory AEM[a]	'model constraints'	law, mandatory measures	application of AEM are mandatory
INT	SUBred60%+ EmaizeWW+ Nred170kg		
EXT	SUBshift70%+ EmaizeSM+ Nred10%		

a) The assumption a farmers' strong willingness to apply AEM is also considered.

Comparison of results of the policy scenarios

The results of the policy scenarios presented in Sections 3.2 to 3.6 are all compared with the baseline scenario CAP2003 described in Section 3.1 and therefore a comparison of these scenarios is possible. In contrast, the results of CAP2003 are related to the reference year REF, which forms a different basis for comparison. Consequently CAP2003 is not considered in the following comparison of the scenarios (cf. Section 2.1).

The policy scenarios in Sections 3.2 to 3.5 present single policy assumptions separately. Therefore the analysis of the scenario results illustrates the impact that the single policy assumption has with regard to the achievement of the particularly addressed policy objectives, as well as with regard to other general stated policy objectives (which can be related positively, neutrally or negatively to the aimed objectives). In the policy scenarios in Section 3.6 the policy instruments from Sections 3.2 to 3.4 are combined in order to simulate and analyze the implementation of a combination of several measures, impacting and interacting in parallel.

The comparison of the results of the scenarios allows for a ranking of the policy instruments according to their impact on the policy objectives. For the ranking the most representative indicators of the targeted policy objectives are selected. Changes in total subsidy and total income volume represent the economic objectives of subsidy reduction and income stability. Changes in cereals area, energy maize area and abandoned UAA represent the impact on the supply objectives food production, energy crop production and retaining UAA. Changes in total nitrogen input and potential AEM area represent the environmental objectives, i.e. reduction of environmental pollution and application of AEM. The ranking of the policy instruments according to their impact on the policy objectives is presented in Tables 4.3-7 and 4.3-8. The rank is derived from the analyis regarding the achievements of policy objectives in all scenarios. The rank values are attributed according to how positively or negatively the simulated instruments impact on the policy objectives. The rank value indicates in which scenario the impact is greater, with equal rank values implying an equal impact in the scenarios. The algebraic sign of the rank value indicates a positive or negative impact and the rank value zero represents a neutral impact on policy objectives.

Table 4.3-7 illustrates the impact of the instruments described in Sections 3.1 to 3.6 on the achievement of the policy objectives in the complete study region BW. For the economic indicators, the changes in subsidy volume and total gross margin are greatest in the scenarios EXT and INT, i.e. when a combination of policy instruments is applied, with the strongest influence coming from the instruments simulated in the subsidy reduction scenarios. The scenario EXT shows the biggest negative impact on TGM (rank value -5) due to the influence of the requirement to reduce N by 10% (as in Nred10%).

The strongest negative impact on cereals area can be found in both combined scenarios, mainly due to the influence of the assumptions from EmaizeWW and Nred10%. Energy maize area is impacted strongest in EmaizeWW, and in combination with other instruments in the scenario INT EmaizeWW drives the demand for energy maize area. Abandoned UAA is impacted the most in Nred10% and is also driven by the instruments in SUBred60% and SUBshift70%. In the scenarios INT and EXT the combination of subsidy reduction, energy crop production and nitrogen restriction result in different developments. In the scenario EXT the combination of instruments from SUBshift70% and from Nred10% result in a strong negative impact on the indicator of abandoned UAA. In scenario INT the impact of EmaizeWW results in a smaller negative impact on abandoning UAA, which also means an improvement in comparison to SUBred60%. This is because increased energy crop production partially compensates the impact of reduced subsidies, with the effect that less UAA falls abandoned.

Total nitrogen input is impacted highest in the scenario EXT, resulting from the instrument applied in Nred10%. The instruments of Nred10% in combination with SUBshift70% result in the second highest positive impact on potential AEM area, which is most negatively impacted in the scenario INT. As expected, the most positive impact for potential AEM can be found in the scenario Mandatory AEM.

Table 4.3-8: Ranking of impact of instruments on policy objectives (represented by selected indicators) in Baden-Wuerttemberg.

Representative indicator	Policy Objective	SUBred60%	SUBshift70%	EmaizWW	EmaizeSM	Nred10%	MandatoryAEM	INT	EXT
Subsidy volume (SUB)	Subsidy reduction	+2	+2	0	0	+1	-1	+3	+3
TGM volume	Income stability	-3	-3	-1	-1	-2	-2	-4	-5
Cereals area	Food production	-1	-2	-5	-3	-6	-4	-7	-7
Energy maize area	Energy production			+4	+2			+3	+1
Abandoned UAA	Retaining of UAA	-2	-3	0	0	-5	0	-1	-4
Total nitrogen input	Reduction of envrionmental pollution	0	0	+1	+1	+3	+2	0	+4
Potential AEM area	Potential AEM area	-3	-3	-4	-2	-1	+2	-5	+1

The impacts of the instruments are partially different when looking at farm types. Table 4.3-9 presents a ranking of the policy instruments according to their impact on the policy objectives at farm type level. According to the definition of farm types the specific NUTS3 counties could then be analyzed in more detail.

In most of the farm types the subsidy volume is most strongly positively impacted in the combined scenarios INT and EXT. However, for the farm type GL-IG the strongest impact results from SUBred60% and SUBshift70%. For most of the farm types the negative impact on TGM is stronger in the combined scenario than in the subsidy reduction scenarios. However, for GL-EG the negative impact on TGM is stronger in the subsidy reduction scenarios.

The rankings of supply indicators show differences in the impacts of the instruments in the subsidy reduction scenarios, energy crop scenarios, Nred10% and their combination in INT and EXT. As in BW the negative impacts of the subsidy reduction scenarios on abandoned UAA are partially compensated by the assumptions of the energy crop scenarios. This reaction can be observed for AL-CC, AL-FC and GL-EC, but not for GL-IG and GL-FC, where the impact on abandoning UAA is the same in the subsidy reduction scenario as in the combined scenarios.

For most of the farm types nitrogen input is impacted the strongest and positively in Nred10% and in EXT. However, for GL-EG the strongest positive impact on nitrogen input is found only in Nred10%. As expected for all farm types, the strongest positive impact on potential AEM area is found in scenario Mandatory AEM. The strongest negative impact is found in scenario INT for all farm types except for GL-IG where the strongest negative impact is found in EmaizeSM.

Table 4.3-9: Ranking of impact of instruments on policy objectives (represented by selected indicators) in farm types.

Representative indicator	SUBred60%	SUBshift70%	EmaizeSM	EmaizWW	Nred10%	MandatoryAEM	INT	EXT	SUBred60%	SUBshift70%	EmaizWW	EmaizeSM	Nred10%	MandatoryAEM	INT	EXT
	Farm type: AL-CC								**Farm type: AL-FC**							
Subsidy volume (SUB)	+2	+2	0	0	+1	-1	+3	+3	+3	+3	+1	+1	+2	-1	+5	+4
TGM volume	-3	-3	-1	-1	-2	0	-4	-4	-5	-5	0	-1	-3	-2	-4	-6
Cereals area	-1	-1	-3	-6	-4	-2	-7	-5	-1	-2	-5	-3	-6	-4	-4	-7
Energy maize area			+2	+3			+4	+1			+4	+1			+3	+2
Abandoned UAA	-1	-1	0	0	-2	0	0	-3	-1	-2	0	0	-4	0	0	-3
Total nitrogen input	0	0	+1	+1	+3	+2	+1	+4	0	0	+1	+1	+2	+2	0	+3
Potential AEM area	-2	-2	-2	-3	-1	+2	-4	+1	-2	-4	-5	-1	-3	+2	-6	+1
	Farm type: GL-IG								**Farm type: GL-FC**							
Subsidy volume (SUB)	+3	+3	-1	0	0	-2	+1	+2	+5	+3	+1	0	+2	0	+4	+6
TGM volume	-2	-2	0	0	-1	0	-3	-3	-2	-2	0	0	-1	-1	-2	-3
Cereals area	-1	0	-2	-2	-4	+1	-3	-1	-2	-1	-4	-3	-5	-5	-3	-6
Energy maize area			+1	+2			+3	0			+3	+2			+2	+1
Abandoned UAA	0	0	0	0	-2	0	0	-1	-2	-1	0	0	-2	0	-1	-3
Total nitrogen input	0	0	+1	0	+3	+2	0	+3	-1	0	0	+1	+3	+2	0	+3
Potential AEM area	-2	-1	-5	-3	+1	+2	-4	+3	-3	-1	-4	-2	+2	+3	-5	+1
	Farm type: GL-EG															
Subsidy volume (SUB)	+3	+1	0	0	+2	0	+3	+3								
TGM volume	-3	-3	0	0	-1	0	-2	-2								
Cereals area	-3	-3	-1	-4	-6	-2	-5	-5								
Energy maize area			+1	+2			+3	+1								
Abandoned UAA	-3	-2	0	0	-1	0	-1	-4								
Total nitrogen input	-2	-2	0	-1	+3	+2	-1	+1								
Potential AEM area	-4	-3	-2	-2	0	+1	-5	-1								

4.4 Discussion of the study: analysis of strengths and weaknesses

In this analysis the strengths and weaknesses of the study are discussed with respect to the methods applied and the outcome of the study.

The weaknesses summarize the shortcomings and caveats of this study. The shortcomings have to be considered for the interpretation of the results because they might bring into question their interpretation and validity. The reasons for the shortcomings are known but they had to be accepted without corrections because modifications are either not possible or require considerable efforts beyond the scope of this work (e.g. the development of new model approaches or model modules, cf. Section 3.3).

The caveats have to be considered but can be accepted for the issue of this study without questioning the validity of the results. Possibilities to correct these caveats can be presented, however, the caveats are accepted and improvements are not tackled within the scope of this study (e.g. a more exact analysis of the results with regard to more differentiated farm types would be possible but is not carried out because the analysis of aggregates chosen is sufficient for this study, cf. Section 3.2). Revealing both the shortcomings and caveats could be considered as recommendable as a starting point for further analysis or model development work.

The strengths summarize ideas which could be topics of future research, as well as the scientific contribution of this study with respect to methods and results. Ideas for further research topics result from revealing the weaknesses and from a further elaboration and development of the original contributions (e.g. application of the model in other modelling frameworks, cf. Section 2.3).

The scientific contributions with respect to methods and results are classified according to the following three groups:

(1) 'Existing methods applied', which describes the analysis or modelling methods which were taken as existing methods and then applied. This section demonstrates the usefulness of the existing methods to deal with the research questions of this study.

(2) 'Existing methods modified and development of new methods', which describes already existing methods that had been adapted, extended or newly developed to address the research questions in this study.

(3) 'New results', which describes the research outcomes produced in this study.

4.4.1 Weakness: shortcomings of the study

The shortcomings revealed in this study comprise the limited resolution to NUTS3, the aggregation error, the modelling of energy maize and the modelling of abandoned UAA.

Limited resolution to NUTS3

The ACRE model used allows the generation of results at NUTS3 county level as the highest resolution. Nonetheless, for some questions of regional policy decision making the analysis of higher resolution than NUTS3 might be of interest because even within NUTS3 counties agricultural production can be highly heterogeneous and thus policy measures can result in different impacts for producers with different production conditions (cf. Section 3.4). A resolution at municipality level (NUTS4) would result in a more exact regional analysis and results could be used for evaluation of impacts on farming close to farm level. However, the availability of statistical data limits the resolution of the model. The statistical production data published at NUTS4 municipality level are censored because in some cases the conclusion from NUTS4 statistics to single farms is possible (cf. Section 2.2). A valid uncensored NUTS4 database level could be used to create a new model with higher resolution at NUTS4 level. However, such a model extension would require a lot of calibration effort for each of the 1101 NUTS4 municipalities.

Aggregation error

The shortcoming of the aggregation error is associated with the data resolution at NUTS3 county level. The regional farms aggregate the production factors at NUTS3 level which does not represent the real situation of factor allocation. For instance the allowed limit of organic nitrogen intensity of 170 kg ha^{-1} organic N is not reached at NUTS3 level (cf. Section 3.4). However, at farm level the intensity of organic nitrogen is expected to be higher for some farms with intensive livestock production. Nevertheless, the aggregation of total UAA and total amount of organic nitrogen results in an average nitrogen intensity below 170 kg ha^{-1} organic N and thus can give no indication if and where the limit might actually be exceeded (cf. Section 3.4).

The analysis of the aggregation error, which was executed with respect to NUTS3 and NUTS2 levels, does not provide information on the aggregation error between NUTS4 municipality level and NUTS3 level. However, the analysis shows that the results for NUTS3 and NUTS2 levels are sufficiently comparable, and thus the model could be used also for calculation at NUTS2 level (cf. Section 2.3).

Modeling of energy maize

The PMP approach applied for model calibration requires historical production data and thus production activities can only be modeled when the representative historical data are available. However, in the case of energy crops historical data are missing and this data limit requires an alternative in order to simulate energy crop production. Therefore the calibration data calculated for silage maize and winter wheat and the production data of silage maize are used as an approximation to simulate the production activity of energy maize. This approximation implies two shortcomings:

(1) The calibration parameters represent exactly the competitiveness of winter wheat and silage maize. A standard PMP approach would not result in a combination of parameters that are exactly the same as the parameters of other crop activities. The use of average values, which result in different calibration parameters as used by Gömann et al. (2005) avoids this problem. However, in combination with production data and price data, the gross margin functions of the energy maize crop activity are different from the other activities.

(2) Differences between production data of silage maize and energy maize. The energy maize production differs in production data from the silage maize production because the production aims at a high biomass yield rather than at a high nutrient value for fodder usage. Thus, silage maize production data are only an approximation to represent energy maize production. Furthermore both crops differ in reality with regard to the working processes and input data (e.g. nitrogen demand). However during the time this study was conducted regional production data of energy maize production were not available.

A calibration of energy maize production using historical data of acreages and crop yields, as well as representative production data, would provide a better representation of energy maize production activity than the applied approximation in this study (cf. Section 3.3).

Modeling of abandoned UAA

The ACRE model used in this study does not simulate abandoned UAA in an appropriate way. This shortcoming results from the limitations in flexibility of the PMP model, from the aggregation error and from the lack of a land market activity. Thus the applied approach does not simulate land allocation as it is expected in reality (cf. Section 3.2).

The consideration of this shortcoming is important for the interpretation of the results of the subsidy reduction scenarios SUBred60% and SUBshift70%. In these scenarios abandoned UAA increases and indicates a negative impact on the supply objective and influences indicators depending on the acreage of UAA under production (e.g. nitrogen intensity). A correction of the shortcoming requires the development of a land market activity or/and the modification of the modeling approach (e.g. by adding land abandoning activities). However, the development of this modeling function was beyond the scope of this study.

4.4.2 Weakness: caveats of the study

The weaknesses in this study include the mapping of VGG and NUTS3, the number of indicators and objectives as well as missing scenarios.

The mapping of VGG and NUTS3

The mapping of VGG and NUTS3 data is based on an optical estimation of the total geographical area of both regional units. For this approach two inexactnesses have to be considered: (1) the imprecision of the optical estimation itself and the resulting inexact weighting by estimated percentages and (2) the measure of total area which does not represent the UAA. Particularly in the extensive regions the total surface cannot be considered as being representative for UAA since a lot of the total area is not used as UAA but for example as forestry area. A mapping based on data at municipality level would provide more exactness in weighting by area data and data mapping. Since the borders of the municipalities are congruent with the borders of the NUTS3 counties and the area numbers of UAA are known at NUTS4 level the exact mapping of the data should be possible. However, at the time of conducting this study the GIS data at NUTS4 were not available (cf. Section 2.2).

Number of indicators and objectives

Indicators and objectives have been selected according to the research questions of this study. However, there might be further objectives of interest for policy decision making for which indicators should be developed. For example objectives concerning structural changes could be implemented by developing indicators which consider farm size and number of farms.

The indicators selected for this study are representative for the analysis of the policy impact on the selected policy objectives. Nevertheless, the list of indicators could be extended by complementary indicators providing even more information for the research questions. For example the analysis of the policy impact on the economic objectives could be extended by an indicator for the development of production costs, as this would allow an even deeper analysis. With respect to the environmental objectives an interesting additional analysis could be on the application of pesticides.[50]

Missing scenarios

The scenarios are selected according to the research questions of this study. However, some scenarios of interest are not considered in this study. For instance, the price scenario selected in this study is based on historical data from 2007. In this year the historical level of producer prices was extremely high for some products (e.g. wheat). In all scenarios the price assumptions are the same. The simulation of scenarios under assumptions of high price levels and low price levels could be of interest, and could also be done as a sensitivity analysis (e.g. for the scenario CAP2003). However, since the price assumptions used in this study are similar to the price forecasts of other institutions and since market developments should be included in market models, the aspect of price development is not addressed in this study (cf. Section 3.1).

4.4.3 Strength: ideas for further research work

Ideas for improving ACRE, as well as the study, include a higher resolution of the regional results, the improvement of modeled activities, and the improvement of the mapping of the VGG data and the farm type definition, as well as cooperation with stakeholders, institutions and in frameworks with other models. Furthermore, in order to solve the caveats and shortcomings, a better data base, and a new calibration or the developments of new model functions are necessary.

Higher resolution of regional results

To reach a higher resolution and aiming to reduce the aggregation error it would be necessary to design a new model which calculates at NUTS4 level. However, due to the high costs of data and calibration work it should be assessed in advance how useful it would really be to

[50] The model includes a module to calculate the application of pesticides and the amount of certain active substances. However, these data have not been analyzed in this study. The legal framework of pesticides allows a usage of certified pesticides for a duration of 10 years. Using this database for calculations of a 15-year period would have required ceteris paribus assumptions for pesticide applications which are unrealistic (cf. Appendix 2.2).

extend the ACRE model to cover all NUTS4 municipalities. It has to be estimated whether or not the resolution could be increased by the selection of some representative municipalities which could represent all NUTS4 regions. A model with higher resolution could contribute to further investigation of the aggregation error. The cooperation with governmental authorities (e.g. StaLa or MLR), which would permit the use of the valid NUTS4 data, would be necessary to create a valid database. In order to overcome censorship due to data privacy, data results could be published only for selected municipalities or could be aggregated to NUTS3 level. The investigation of the aggregation error between the scales of NUTS3 county level and NUTS4 municipality level could be a topic of further research when reliable NUTS4 data are available.

Implementation of further production activities and land abandoning

Another research topic for improving ACRE is the modeling of energy maize production. A more representative modeling of energy maize production might be achieved by an update of the base year with the available regional data for energy maize production. As the statistical data survey takes place every four years the most recent survey is for the year 2007 or 2011.

Out of the analyzed AEM from MEKA 3 only some are modeled as indicators and not as real production activity. Further work could be done to implement more AEM activities into the model. Also the development of an approach to implement the AEM as production activities into the model could be envisaged.

To improve the modeling of abandoned UAA in ACRE there is a need to imply land abandonment as an activity or as land market functionality. However, since area payments from Pillar 1 might have the effect of keeping UAA under agricultural management, it might actually be difficult to find the necessary historical data for land abandonment in the study region which allow calculation of a shadow price for the calibration. Ideas on how to create a land market function for a supply model could be taken from the RAUMIS model which considers trade with land (cf. Section 2.3).

Mapping of VGG with exact UAA data and definition of farm types

The mapping in ACRE could be improved by using GIS data that provide exact information of UAA acreages for the identification of the NUTS4 municipalities which are situated in the corresponding VGG. The NUTS4 municipalities are congruent with the natural borders of VGG and with the administrative borders of NUTS3 regions. The GIS data are now available but they were not available at the time when this study was conducted. Using the exact data of

UAA provides on the one hand a more exact weighting of the natural production conditions (e.g. temperature and altitude) which could be calculated for the NUTS3 regions. On the other hand the simulation results could be transferred from the NUTS3 counties to NUTS4 municipalities and then be aggregated to the natural regions of VGG. The information regarding policy impacts on agricultural production might be of interest for the analysis of the regions of VGG especially with respect to environmental aspects.

The development of complementary indicators and the analysis of additional policy objectives and/or additional policy scenarios might be of interest for decision makers as well as for research purposes. The cooperation with stakeholders (i.e. the policy makers) and with other institutions could provide further ideas for such new research tasks.

The farm type approach taken in ACRE might be improved by the selection of different benchmarks or by including different statistical data for their definition (e.g. number of farms or farm size). The improvement of this approach could be a task for further development, however, for this study the selected farm type approach is sufficient to address the research questions.

Cooperation with stakeholders, institutions and frameworks with other models

Cooperation with the regional policy decision makers of the study region, or for BW and BY separately, could reveal the need for further scenario simulations in which stakeholders are interested. Specific questions from stakeholders could be used as an incentive for the further development of the ACRE model as a regional specific tool to address regional topics for Southern Germany. One particular topic of potential interest for stakeholders is structural change. Consideration of structural change would require the development and implementation of additional indicators and model functions. Other scenarios could be calculated according to the interest of the stakeholders (e.g. defined ranges of reduction of direct payments).

The cooperation with other economic or biophysical models would allow the building of model chains by using output data from other models as input data for ACRE. For instance ACRE could use changes in price data simulated by a market model. Also the implementation into a modelling framework might be possible. The ACRE model for Southern Germany could be further developed as a specified satellite model in RAUMIS, in order to address specific questions not covered by RAUMIS. ACRE could for example complementarily represent the region Southern Germany with a focus on special issues like environmental policy questions. In this context ACRE could even be embedded in the vTI modeling framework (cf. Section 2.3).

A general comparison of model results in ACRE and RAUMIS for the region Southern Germany or BW might also be of academic interest in order to analyze and improve the model behavior. However, such a comparison of simulation results of different models requires a detailed description and comparison of common and different parameters and functions, as well as a model harmonization where possible.

4.4.4 Strength: scientific contribution of the study

The scientific contribution of this study includes the application of existing methods, the application of existing methods which have been modified and the development of new methods, as well as new outputs.

Applied existing methods

In order to answer the research questions of this study the existing regional model ACRE-Danube has been extended from the model region of the Danube catchment area to the model region Baden-Wuerttemberg (cf. Section 2.3). Additionally the model region has been enlarged by the region Bavaria, resulting in the extended model version ACRE-SouthernGermany, which is able to simulate agricultural production at regional level for the complete model region Southern Germany. The reference year has been updated to the year 2000 and the model has been extended by some production activities (e.g. energy maize production, wine production) and indicators (e.g. abandoning of UAA, erosion potential, AEM area, pesticide application)[51].

The underlying methods on which the model is based are: a process analytical approach, the regional farm approach and the calibration according to the PMP method. The model is built with the function to calculate at two different regional scales: at NUTS3 county level and at NUTS2 district level. This function can be used for the analysis of the aggregation error and for the analysis at NUTS3 and NUTS2 levels.

The analysis of the model results is structured according to an indicator objective framework. The investigated policy objectives are defined according to the research questions and officially stated policy objectives. The adequate indicators are used to analyze the impacts of

[51] However the activity of wine production and the indicator pesticide application were not presented or used in this study.

simulated policy scenarios on agricultural production at regional level and on the achievement of the policy objectives. The indicator objective framework allows for a structured analysis of several policy objectives and scenarios.

The method of sensitivity analysis is used to define the range of subsidy reduction as well as the producer price of energy maize in the corresponding scenarios (cf. Section 3.3). Thus, in contrast to other studies, the sensitivity analysis has been used in this study for scenario definition and not for investigation of the model reaction with respect to certain parameters. The investigation of the model behavior under variation of interesting parameters (e.g. variation of prices) could be envisaged as further research work.

In order to investigate the forecast quality an ex-post analysis was carried out. The ex-post analysis was done for the complete model region at NUTS2 district level and at NUTS3 county level. The simulation period from 2000 to 2015 implies relatively extreme changes in the CAP due to the CAP 2003 reform. The ex-post analysis shows a satisfying forecasting quality for the complete model region as well as for the sub-regions (i.e. NUTS3 and NUTS4 regions) and for different products. Thus, the model could be validated as being appropriate for use in this study.

In the scenarios, changes of payments and of prices, mandatory measures and promotion of alternative production activities under different market conditions are simulated. For this issue the following different modeling techniques are used to represent the policy assumptions in an appropriate way: 'variation of parameter values', 'model constraints', 'additional crop production activity' and 'calibration with different shadow prices' (cf. Sections 3.1 to 3.6 and Section 4.1).

Applied existing methods modified and development of new methods

A 'farm types approach' is developed for the study region and used in order to summarize the scenario results and to transfer the results to more general units than specific NUTS3 regions. The farm types are clusters of NUTS3 regions with similar production patterns, i.e. they represent the regional distribution of similar farming patterns in the study region. The farm types are defined according to certain upper and lower benchmarks of statistical land use data (i.e. the share of arable or grassland, the share of cash crop and fodder crop area and of extensive and intensive grassland). The number of NUTS3 counties from which the farm types are created is biased. For example there are only three counties with an high share of intensive grassland farming to be counted as farm type GL-IG, while the farm type AL-CC is based on 15 NUTS3 counties where natural conditions allow for a dominating cash crop production. Thus, farm type AL-CC can be regarded as being much better represented than GL-IG (cf. Section 2.2).

To analyze the impact of policy changes on AEM, an indicator to measure potential AEM area was developed. The AEM area indicator was defined for selected AEM of the agri-environmental program MEKA3 and thus does not cover all AEM. Due to the lack of historical data AEM activities could not be implemented as calibrated activities into the PMP model. Nevertheless, the indicator is able to measure the area where AEM could be applied. The potential AEM area is counted as an indicator in order to analyze the impact of policy measures on the application of AEM, which is a new method introduced in the ACRE model (cf. Section 3.5).

The investigation of the aggregation errror via an ex-post analysis for NUTS3 and NUTS2 regions is an adapted method, which was newly applied to the ACRE model. The results lead to the conclusion that the aggregation error between the different scales NUTS3 and NUTS2 is within an acceptable range.

In order to simulate energy crop production, a method according to Gömann et al (2005) was modified. Gömann et al (2005) used the average value of the calibration parameter of the regional leading crops, which were winter wheat or winter barley, in order to represent the calibration parameter for energy maize. In this study the calibration parameters of silage maize and winter wheat are used as the calibration parameter for energy maize. Both parameters are used to simulate scenarios with different competitiveness between energy maize production and food production, which result from different market and policy assumptions for energy (e.g. assumption of energy maize demand, promotion of energy economic measures). Using the method of 'calibration with different shadow prices' the calibration parameter of silage maize and winter wheat are used for the simulation of two different energy market scenarios. This means technically the application of different non-linear gross margin functions for the production activities in the scenarios (cf. Section 3.3). The traditional way to modify the gross margin functions in order to simulate scenarios is to vary exogenous parameters like prices, yields or subsidies. The simulation of scenarios through the use of different calibration parameters is adequate because these calibration parameters are only proxz data which are assumed to represent energy maize production activity and historical representative data are not known. One of the advantages of this method might be seen to be the possibility of keeping the exogenous parameter (e.g. prices) in the scenarios ceteris paribus.

New outputs

In other studies agricultural production is described for the study region as a whole (e.g. Arndt 2005) or for the VGG (e.g. MLR 2008A). In this study the agricultural production conditions are described at NUTS3 level and derived from the data of the natural regions VGG. A description and display in this form is new for the study region Baden-Wuerttemberg.

The ACRE version used in this study simulates agricultural production at NUTS3 and NUTS2 levels for Southern Germany and is, in this form, a new research model. The comparable APM RAUMIS simulates agricultural production only at NUTS3 level. Basically RAUMIS could also have been used to address the research questions of this study, however ACRE has the advantage that it is specified for and tailored to the region Southern Germany. With its relatively simple structure, ACRE allows for an easier model development to address the specific adaptations needed in this study than would have been the case with the RAUMIS model. The use of the variant activity approach of the PMP method enables the ACRE model to calculate in different production intensities, which is especially suitable and important for addressing agri-environmental questions.

In the literature several impact studies based on expert knowledge or APM analysis exist (e.g. EC 2006C, SABAP 2005, vTI 2010). However, these studies do not specifically address the study region BW. The analysis of this study was done specifically for BW at three different levels: for the complete study region BW, for farm types and for NUTS3 counties. The scenario results are, in this form, new research output of agricultural policy analysis specifically addressing the study region Baden-Wuerttemberg. The analysis comprises a broad spectrum of scenarios addressing baseline policy (CAP2003), reformed subsidy policy (e.g. SUBred60%), energy production (e.g. EmaizeSM), environmental policy (e.g. Nred10%) and agri-environmental programs (mandatory AEM). The scenarios simulated give information on policy issues of current interest and thus can be useful for regional decision makers as decision support for the implementation of agricultural policy measures. In the two scenarios INT and EXT the single policy instruments of the other scenarios are combined in order to represent a possible set of policy instruments. The analysis of these combined scenarios provides information on the impact of the interacting single instruments on the policy objectives. In a specific rank analysis the impacts of the single instruments of all scenarios are compared with each other with respect to BW and to the farm types. This analysis provides an indication of how strong the impacts of the different instruments are separately and if they are applied in combination.

4.4.5 Concluding remarks

Table 4.4-1: Overview of the results of the strengths and weaknesses of the study.

Strengths
Scientific contribution
Applied existing methods:
Extension of model to ACRE-SouthernGermany
Extension by indicators and activities
Extension by NUTS2 regions
Calculation of forecasting error
Application of different modeling techniques to simulate policy instruments
Applied extended and developed methods:
'Farm type' based analysis
Indicator of AEM area
Investigation of the aggregation error via an ex-post analysis
Simulation of energy crop production activity of different competitiveness
New outputs:
Description of agricultural production conditions at NUTS3 level
New ACRE versions: ACRE-BW, ACRE-BY, ACRE-SG
agricultural policy analysis of different scenarios with single policy instruments
agricultural policy analysis of scenarios with combinations of single policies instruments
Ranking of the impact of the single instruments in the scenarios
Ideas for further research work
Higher resolution of regional results (e.g. NUTS4 level)
Implementation of production activities and land abandoning
Mapping of VGG and further definition of farm types
Cooperation with stakeholders, institutions and frameworks with other models
Weaknesses
Caveats
The mapping of VGG and NUTS3
Number of indicators and objectives
Missing scenarios
Shortcomings
Limited resolution to NUTS3 level
Aggregation error
Modeling of energy maize
Modeling of abandoned UAA (no land market)

The results of the strengths and weaknesses analysis are summarized and presented in the Table 4.4-1.

Agricultural production in Baden-Wuerttemberg is regionally heterogeneous and of high importance. This study introduces the regional supply model ACRE and presents an agricultural policy analysis of different scenarios for the study region. The analysis investigates the impact of simulated policy measures on agricultural production and the achievement of policy objectives, and allows conclusions to be reached with regard to the suitability of the policy measures. The analysis shows that the impacts of the simulated policy measures are regionally quite diverse and hence a regionally adapted implementation of CAP instruments is required in order to address and efficiently achieve economic, supply and environmental policy objectives. The validation and the results of the study also show that ACRE is a suitable tool for regional agricultural policy analysis and policy decision support. Supplementary work could help to overcome distinct caveats and to further develop the model. However, ACRE can already be used now as a useful tool for the regional agricultural policy analysis of the CAP in Baden-Wuerttemberg.

5 Summary

Since its introduction the Common Agricultural Policy (CAP) of the European Union (EU) has undergone several reforms in order to adapt policy instruments and enable the agricultural sector to fulfil multiple functions with respect to economic, supply and environmental objectives. In the German federal state Baden-Wuerttemberg agricultural production is characterized by regional heterogeneity. Therefore it is important to estimate the impacts resulting from changes in the CAP at a detailed regional level. In this study the agricultural policy model ACRE (Agro-eConomic pRoduction model at rEgional level) has been used to simulate different policy scenarios and to analyze regional economic, production and environmental impacts. In particular the study aims to address the following research questions:

What are the regional impacts of different policy measures in the German federal state Baden-Wuerttemberg with respect to economic, production and environmental objectives? How suitable are the simulated policy measures for achieving the policy objectives of the CAP 2003 reform, as well as the objectives of subsidy reduction, promotion of energy crop production, reduction of environmental pollution and promotion of agro-environmental measures? How suitable is the regional supply model ACRE as a tool for policy analysis and policy decision support?

In order to address the research questions, ACRE has been updated, adapted and extended to simulate agricultural production in the federal state Baden-Wuerttemberg at NUTS3 level. The policy scenarios simulated in this study are defined to cover recent discussions on the future development of the CAP and their results are analysed according to a regional framework for NUTS3 counties, farm types and the complete model region.

The simulation of the reference year (REF) implies the policy reform Agenda 2000 in the simulation year 2000. Thus, REF represents the observed situation of regional agricultural production on whose statistical data ACRE is calibrated. The scenario CAP2003 simulates the policy measures of the CAP 2003 reform in the simulation year 2015. Assumptions of increased yields and prices as well as harmonized direct payments for arable land and grassland result in an increase in income as well as in an increase of subsidy volume. In the entire model region Baden-Wuerttemberg cereal production increases while the production of fattening bulls and pigs decreases. Increases in crop production intensity result in an increase in environmental pollution. The scenario CAP2003 is used as the baseline scenario to compare the results of simulated policy scenarios which are delineated in the following paragraphs only with the most important results for the complete model region Baden-Wuerttemberg.

In two subsidy reduction scenarios the simulated policy instruments aim to reduce subsidy volume by reducing Pillar 1 payments by 60% and by shifting 70% of the money from Pillar 1 to Pillar 2 respectively. Both scenarios result in the positive impact of a decrease in subsidy volume, but show a negative impact, especially an increase of abandoned land.

In two energy crop scenarios the production of energy maize is simulated under the assumption that different situations in energy policy and energy markets result in different competitiveness between production of energy maize and food. In both scenarios energy crop production partially replaces cereal production, although the extent varies according to the high or small level of competitiveness between production of energy maize and food. Impacts on agricultural income and subsidies are small while increased environmental pressure is expected in the event of a significant expansion in energy crop production.

Two nitrogen reduction scenarios simulate policy measures according to the water framework directive (WFD) and the OSPAR convention. The scenario according to the WFD (limitation of organic nitrogen input to a maximum of 170kg nitrogen per hectare) does not result in any impacts. In contrast, the scenario according to the OSPAR convention (reduction of nitrogen input quantities by 10%) results in a decrease in environmental pollution and is accompanied by a reduction of income and reduction of agricultural production under land abandonment.

In the scenario of mandatory agri-environmental measures (AEM) it is assumed that the area with applied AEM is extended. The increase of AEM area results in a decrease in cereal production and a reduction of environmental pollution, while income decreases only slightly.

Two combined scenarios simulate a mix of different policy and market situations which provoke an intensive and an extensive agricultural production. The results of these scenarios illustrate the interaction of the single policy measures. The measures of subsidy reduction have similar reducing impacts on income and subsidy volume in both scenarios. In the intensive production scenario high competitive energy crop production and a less restrictive nitrogen restriction result in a compensation effect of land abandonment by extension of energy crop area. In the extensive production scenarios, less competitive energy crop production and a high restrictive nitrogen constraint result in reduced agricultural production, increased land abandonment and reduced environmental pressure.

In order to evaluate the impact of the simulated policy measures on the achievement of policy objectives the results of all scenarios are compared and ranked according to their impact on the policy objectives. The analyses of the model results show impacts of policy measures which are likely to be expected. However, the analyses at NUTS3 as well as farm types' level reveal that the impacts of the policy measures can be regionally quite different. Thus the detailed regional model results clearly show that (and where) the implementation of agricultural policy measures requires a regional specific evaluation and monitoring. In order to discuss the study with regard to the methods applied and the outcome, a final strengths and weaknesses analysis was conducted. The analysis highlights the strengths of the study (e.g. the model validation, the regional analysis of different policy scenarios, the possibility of cooperation with regional stakeholders). The validation and the results of the study also show that ACRE is a suitable tool for regional agricultural policy analysis and policy decision support. Supplementary work could help to overcome single shortcomings and caveats and to further develop the model. However, ACRE can already be used now as a useful tool for the regional agricultural policy analysis of the CAP in Baden-Wuerttemberg.

6 Zusammenfassung

Seit ihrer Einführung wurde die Gemeinsamen Agrarpolitik (GAP) der Europäischen Union (EU) mehrmals reformiert und ihre Politikinstrumente angepasst um der Multifunktionalität des Agrarsektors im Hinblick auf ökonomische Ziele, sowie Produktions- und umweltrelevante Zielsetzungen gerecht zu werden. Im deutschen Bundesland Baden-Württemberg ist die Agrarproduktion regional sehr heterogen. Daher ist es notwendig die Auswirkungen die sich aus Änderungen in der GAP ergeben auf regionaler Ebene detailliert zu untersuchen. In dieser Studie wurde das Agrarpolitikmodel ACRE (Agro-eConomic pRoduction model at rEgional level) angewendet um verschiedene Politikszenarien zu simulieren und die entsprechenden regionalen ökonomischen, Produktions- und Umweltauswirkungen zu analysieren. Die Studie adressiert insbesondere folgende Fragestellungen: Welche regionalen Auswirkungen haben unterschiedliche Politikmaßnahmen im deutschen Bundesland Baden-Württemberg in Bezug auf ökonomische, Produktions- und umweltrelevante Zielsetzungen? Wie geeignet sind die simulierten Politikmaßnahmen um die angestrebten Politikziele Reduzierung der Prämienzahlungen, Förderung von Bioenergiepflanzenproduktion, Reduzierung von Stickstoffeintrag und Ausweitung von Agrarumweltmaßnahmen zu erreichen? Wie geeignet ist das regionale Produktionsmodel ACRE als Instrument zur Politikanalyse und Politikberatung?

Zur Beantwortung der Forschungsfragen wurde ACRE aktualisiert, angepasst und erweitert um die Agrarproduktion in Baden-Württemberg auf NUTS3 Ebene zu simulieren. Die in dieser Studie simulierten Politikszenarien wurden so gestaltet, dass sie die Aspekte der aktuellen Diskussion über die zukünftige Entwicklung der europäischen Agrarpolitik repräsentieren. Die Szenarienergebnisse werden jeweils auf NUTS3 Ebene, für Farmtypen und für die gesamte Modelregion analysiert.

Die Simulation des Basisjahres (REF) impliziert die Agrarpolitikreform Agenda 2000 im Simulationsjahr 2000. Somit repräsentiert REF die beobachtete Situation der regionalen Agrarproduktion auf deren statistischen Basisdaten ACRE kalibriert wurde. Das Szenario CAP2003 simuliert Politikmaßnahmen der Agrarpolitikreform GAP 2003 im Simulationsjahr 2015. Sowohl die Annahmen von steigenden Erträgen und Preisen als auch harmonisierte

Direktzahlungen für Ackerland und Grünland bewirken einen Anstieg von Einkommen und Prämienvolumen. In der gesamten Modelregion Baden-Württemberg steigt die Getreideproduktion während die Produktion von Bullen und Schweinen sinkt. Der Intensitätsanstieg in der Pflanzenproduktion hat einen Anstieg der Umweltbelastung zur Folge. Das Szenario CAP2003 wird als Referenzszenario benutzt mit welchem die Ergebnisse der anderen simulierten Politikszenarien verglichen werden. Nachfolgend werden die wichtigsten Ergebnisse der weiteren Politikszenarien für die gesamte Modelregion Baden-Württemberg kurz beschrieben.

In zwei Prämienreduzierungsszenarien adressieren die simulierten Politikinstrumente das Ziel einer Reduzierung des Prämienvolumens in unterschiedlicher Weise. In einem Szenario werden die Zahlungen der Ersten Säule um 60% reduziert und im anderen Szenario werden 70% der Budgetzahlungen von der Ersten Säule zur Zweiten Säule verschoben. Die Ergebnisse beider Szenarien zeigen sowohl die positiven Auswirkungen auf das Prämienvolumen als auch die negativen Auswirkungen in Form von sinkendem landwirtschaftlichem Einkommen und aus der Produktion fallende Agrarflächen.

Zwei Energiepflanzenproduktionsszenarien simulieren die Produktion von Energiemais, unter der Annahme dass unterschiedliche Gegebenheiten in der Energiepolitik und des Energiemarktes zu einer unterschiedlichen Wettbewerbsfähigkeit zwischen der Produktion von Energiemais und Nahrungsmitteln führt. Die Ergebnisse zeigen, dass die Auswirkungen auf das landwirtschaftliche Einkommen und Prämienvolumen gering sind, hingegen wird im Falle einer starken Ausweitung der Energiemaisproduktion eine steigende Umweltbelastung erwartet.

In zwei Stickstoffreduzierungsszenarien werden die Politikmaßnahmen der Wasserrahmenrichtlinie (WRL) und der OSPAR Konvention simuliert. Im WRL Szenario zeigt die Limitierung des Eintrags von organischem Stickstoff auf maximal 170kg Stickstoff pro Hektar keine Auswirkungen. Im Gegensatz dazu zeigt das OSPAR Szenario (Reduzierung des Stockstoffeintrags um 10%) eine abnehmende Umweltbelastung, während das landwirtschaftliche Einkommen und die Agrarproduktion zurückgehen und Agrarflächen aus der Produktion fallen.

Im Szenario der verbindlichen Agrarumweltmaßnahmen (AUM) wird eine Ausdehnung der Flächen die nach entsprechenden AUM bewirtschaftet werden angenommen. Die Ausdehnung der AUM bewirkt einen Rückgang der Getreideproduktion und eine Verminderung der Umweltbelastung begleitet von nur gering sinkendem Einkommen.

Zwei kombinierte Szenarien simulieren Kombinationen aus verschiedenen Politik- und Marktsituationen, welche entweder eine intensive oder extensive Agrarproduktion zur Folge haben. Die Ergebnisse dieser Szenarien veranschaulichen die gegenseitigen Wechselwirkungen einzelner Politikmaßnahmen. Die Maßnahmen der Prämienreduzierung haben in beiden Szenarien ähnliche Auswirkungen auf das Einkommen und Prämienvolumen. Im intensiven Produktionsszenario bewirken die hohe Wettbewerbsfähigkeit der Energiepflanzenproduktion und eine weniger bindende Stickstoffrestriktion eine Ausdehnung der Energiemaisproduktion und kompensieren damit die Effekte die sich durch das Brachfallen landwirtschaftlicher Nutzfläche ergeben. Im extensiven Produktionsszenario bewirken die geringere Wettbewerbsfähigkeit der Energiepflanzenproduktion und die stark bindende Stickstoffrestriktion eine sinkende Umweltbelastung, einen Rückgang der Agrarproduktion sowie eine Zunahme der Brachflächen.
Um die Auswirkungen der simulierten Politikmaßnahmen auf die angestrebten Politikziele zu evaluieren wurden die Ergebnisse aller Szenarien verglichen und entsprechend ihrer Wirkung auf die Politikziele klassifiziert. Die Analyse der Modelergebnisse zeigt vorwiegend absehbare Auswirkungen der Politikmaßnahmen. Allerdings veranschaulichen die Analysen auf NUTS3 Ebene und der Farmtypen, dass die Auswirkungen der Politikmaßnahmen regional sehr unterschiedlich sein können. Die regionalen Modellergebnisse verdeutlichen somit, dass (und wo) agrarpolitische Maßnahmen eine regional spezifische Evaluierung und Beobachtung erfordern. Die Studie wird abschließend anhand einer Stärken-Schwächen-Analyse im Hinblick auf die angewandten Methoden und Ergebnissen diskutiert. Die Analyse zeigt insbesondere die Stärken der Studie auf, wie z.B. die Modellvalidierung, die regionalspezifischen Ergebnisse und die Möglichkeit einer weiterführenden Kooperation mit regionalen Stakeholdern. Die Validierung und die Ergebnisse der Studie belegen dass ACRE ein geeignetes und nützliches Modell zur regionalen Politikanalyse der GAP in Baden-Württemberg ist.

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Agro-economic policy analysis with the regional production model ACRE – A case study for Baden-Wuerttemberg

Appendix

Dissertation zur Erlangung des
Grades eines Doktors der Agrarwissenschaften

von
Martin Henseler
aus Oberhausen
2011

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1 Introduction

1.1 Policy background

Table 1.1-1: Overview of the different periods of CAP, with their reforms, the problems, policy objectives and policy instruments.

Period	Reforms	Problems to be solved:	No.	With respect to the objectives:	With the instruments:
Time after WWII 1950th to 1980	Treaty of Rome (1957)	Weak agricultural production	A	Increase of agricultural productivity	Price support
		Weak agricultural production	B	Ensuring a fair standard of living for the agricultural community	Product support by price policy
		Weak markets	C	Stabilization of markets	Product support by price policy
		Food scarcity, Weak agricultural production	D	Assurance of the availability of supplies	Product support by price policy
		Food scarcity, Weak agricultural production	E	Ensuring of supplies to consumers at reasonable prices	Product support by price policy
CAP between the 80th and 1991	Initiation of CAP	Oversupply, not market oriented production	A	Increase of agricultural productivity	Producer support by coupled direct payments and decreased product support by price policy
		High public expenditures, transparency of transfer payments	B	Ensuring a fair standard of living for the agricultural community	dto.
		Market distortion	C	Stabilization of markets	dto., production quota for milk (1984)
			D	Assurance of the availability of supplies	dto.
			E	Ensuring of supplies to consumers at reasonable prices	dto.
CAP between 1992 and 2004	Mc Sharry reform (1992), Agenda 2000	Oversupply, not market oriented production	A	Increase of agricultural productivity	Pillar 1: Producer support by coupled direct payments and decreased product support by price policy
		High public expenditures, transparency of transfer payments	B	Ensuring a fair standard of living for the agricultural community	dto.
		Market distortion	C	Stabilization of markets	dto., production quota for several productions (e.g. milk, sugar), compulsory set-aside
			D	Assurance of the availability of supplies	dto.
			E	Ensuring of supplies to consumers at reasonable prices	dto.
		Environmental problems due to intensive production	F	Environmental issues	Pillar 2: Agri-environmental programs

Period	Reforms	Problems to be solved:	No.	With respect to the objectives:	With the instruments:
CAP between 2005 and 2013	CAP 2003 reform	Increased demand for food and energy	A	Increase of agricultural productivity	Pillar 1: Decoupled direct payments, abolishing of compulsory set aside and quotas
		High public expenditures, transparency of transfer payments	B	Ensuring a fair standard of living for the agricultural community	dto.
		Market distortion	C	Stabilization of markets	dto., price support only as safety net for price volatility
			D	Assurance of the availability of supplies	dto., cross compliance
			E	Ensuring of supplies to consumers at reasonable prices	dto., Cross Compliance
		Environmental problems due to intensive production	F[a]	Environmental issues and climate change	Cross Compliance , Pillar 2: Axis 2, strengthen of Pillar 2 (e.g. by modulation), promotion of energy crop production
			G[a]	Rural Development	Pillar 2: Axis 1+3, strengthen of Pillar 2, promotion of energy crop production
CAP after 2013	preparation by the CAP Health Check 2008	Increased demand for food and energy	A	Increase of agricultural productivity	Pillar 1: decoupled direct payments reduced to a basic payment
		High public expenditures, transparency of transfer payments	B	Ensuring a fair standard of living for the agricultural community	dto.
		Market distortion	C	Stabilization of markets	dto., price support only as safety net for price volatility
			D	Assurance of the availability of supplies	dto., simplified cross compliance
			E	Ensuring of supplies to consumers at reasonable prices	dto., simplified cross compliance
		Environmental problems due to intensive production	F[a]	Environmental issues and climate change	Simplified Cross Compliance , Pillar 2: Axis 2, strengthen of Pillar 2 (e.g. by modulation), new SMR
			G[a]	Rural Development	Pillar 2: Axis 1+3, strengthen of Pillar 2, promotion of energy crop production

Notes: No.: numerations according to the Treaty of Lisbon (2008). dto.: dito, as in the Period and reform before. a) The objectives F and G are not given by the Treaty of Lisbon (2008) but added separate objectives for this study.

2 Theoretical framework of policy analysis and description of the study region and of ACRE

2.1 Objectives and indicators

2.1.1 Appendix: Objectives and indicators

Explanation of the indicator values

Change of subsidy volume

The change of subsidy volume is calculated as the percentage deviation from the reference situation. ACRE calculates the subsidy volume as the sum of all payments from Pillar 1 (direct payments for crop and animal production) and from Pillar 2 (compensatory allowance, payments for the AEM for intensive and extensive grassland and intercropping) Payments amount from Pillar 1 and Pillar 2 are also calculated separately, separately.

$$\text{Change of Subsidy volume} \qquad = 1 - \frac{SUB_{SCEN}}{SUB_{REF}} \qquad \text{Eq. A 2.1.1}$$

with
SUBREF: Subsidy volume in reference scenario
SUBSCEN: Subsidy volume in policy scenario

Change of total gross margin

The change of total gross margin (TGM) represents the development of agricultural income as percentage deviation from the reference situation. TGM is calculated in two different ways: (1) as total gross margin including subsidies from Pillar 1 and 2 (TGM volume incl. SUB) (2) as total gross margin excluding payments from Pillar 1 and 2 (TGM volume excl. SUB).

$$\text{Change of Total gross margin} \qquad = 1 - \frac{TGM_{SCEN}}{TGM_{REF}} \qquad \text{Eq. A 2.1.2}$$

with
TGM: total gross margin

Change of crop and animal production and land use

The change of agricultural production activities is calculated as the percentage deviation from the reference situation.

The change of the extension of production of food and energy crops and animal production is used as indicator to measure the impact on the supply objectives. The changes in crop production are measured in percentage points of UAA, because this allows for a better comparison of the changes with respect to crops of extremely different acreages. The percentage change depends strongly on the initial acreage in the reference situation, which can be very different for crop production. To indicate changes in crop production the following categories of crops are selected are cereals, maize, fodder crops, root crops, oil seeds and legumes, energy maize and others (including special crops, as fruit, wine, vegetables). Further indicators for changes in supply are converted arable and grassland area, intensive and extensive grassland, and abandoned UAA. Changes in animal production are measured in percentage changes of animal numbers of dairy cows, fattening bulls and pigs.

Changes in intensive crop area and intensive production variant area are used to describe to analyse the impact on environmental objectives. Conversion of grassland (GL) into arable land (AL) represents an indicator for supply as well as for intensification. On the contrary, the conversion from intensive land use for AL to extensive land use for GL represents an extensification and indicates a reduction of UAA used for agricultural production. Furthermore, changes in intensive and extensive grassland indicate changes in production intensity, either in the direction of intensive grassland management or extensive grassland management without fertilization and few cuttings. Abandoned UAA is area which falls out of production and indicates an extensification of agricultural production. However, this indicator is also a measure for landscape management. Abandoned UAA is not anymore managed for landscape issues by producers. On the one hand it indicates an environmental damage by succession of landscape. On the other abandoned UAA means an extensification of production and less environmental pressure. However, abandoning UAA might be associated with intensification of agricultural production focussed in most productive areas where environmental pressure might increase.

The indicator intensive crop area reflects changes in insensitivity of agricultural land use, with the group of intensive crops including winter wheat, spring and winter barley, oilseeds, legumes, root crops, maize and special crops. The intensive crop variant includes the intensive arable crop variant and the intensive grassland variants.

Change of crop area $$= \frac{CROP_{SCEN}}{UAA_{REF}} - \frac{CROP_{REF}}{UAA_{REF}}$$ *Eq. A 2.1.3*

with
CROP: crop acreage
UAA: Utilized agricultural area

Change of animal numbers $$= 1 - \frac{ANIM_{SCEN}}{ANIM_{REF}}$$ *Eq. A 2.1.4*

with
ANIM: animal number

Nitrogen intensity, soil erosion and GHG emissions

Changes in nitrogen intensity represent the change of applied nitrogen per UAA in agricultural production from fertilization and manure deposition, and thus they are an indicator for environmental pollution. This implies that if UAA falls abandoned a stable or decreased total nitrogen amount can also result in an increased nitrogen intensity because the divisor area decreases.

To indicate changes in nitrogen input the changes of the total nitrogen input (Nitrogen total) are the most important ones. The total nitrogen input is the sum of the organic nitrogen from livestock and the mineral nitrogen demanded by crop production.

Change of nitrogen input $$= 1 - \frac{Ninput_{SCEN}}{Ninput_{REF}}$$ *Eq. A 2.1.5*

with
Ninput: nitrogen input

The erosion potential represents the relative potential of soil erosion for arable crops. The erosion potential is the sum of the soil erosion factors, the so called C-factors, of all arable crops in relation to the total arable area. The C-factor represents the percentages erosion potential related to uncovered set-aside, which is defined as to be 100%. Depending on the crop management the specific crops have high erosion factors (e.g. maize 27%) or small erosion factors (e.g. oats 6%). Table 2.2-1 presents the values of the soil erosion potential of different crops.

Table 2.1-1: C-factors to calculate the erosion potential.

Crop	C factor % of uncovered fallow land
Winter wheat	6.8
Spring wheat	5.6
Winter barley	9.3
Spring barley	7.4
Rye	4.9
Oat	6.4
Triticale	6.8
Winter rapeseed	11.2
Late potatoes	23.5
Early potatoes	23.5
Sugar beet	21.3
Grain maize	27.2
Corn Cobb Mix	27.2
Silage maize	27.2
Set aside	0.0 (uncovered set aside would be 100%)
Clover	1.0 (own estimation)
Sunflowers	8.0
White cabbage, vegetable	40.0
Grassland	0.0

Source: Hoegen (1995), Kantelhardt (2003: 250)

The change of erosion potential compares the erosion potential of reference situation with the erosion potential in scenario. Being percentage measures (percentage of erosion potential of uncovered set aside) the change is expressed in percentage points.

$$\text{Change of erosion potential} = 1 - \frac{Eropot_{SCEN}}{Eropot_{REF}} \qquad \text{Eq. A 2.1.6}$$

$$Eropot_{SCEN} = \sum_{CROP} \left(\frac{CROP_{SCEN}}{\sum_{CROP} CROP_{SCEN}} * C - factor_{CROP} \right) \qquad \text{Eq. A 2.1.7}$$

with
Eropot: erosion potential
CROP: arable crops
C-factor:C-factor for arable crops

The indicator greenhouse gas (GHG) emissions indicates changes in GHG emissions produced by agricultural production in comparison to the reference situation. GHG emissions result from three important sources: enteric fermentation and manure management, which both result in methane (CH_4) emission, and fertilization with mineral fertilizer which provokes nitrous oxide (N_2O). GHG emissions are calculated in terms of global warming potential in CO_2 equivalents, representing the impact of the gasses on global warming in comparison to CO_2. CH_4 affects global warming 21 times than CO_2 and the CO_2 equivalent for N_2O is 310.

$$\text{Change of GHGem} = 1 - \frac{GHGem_{SCEN}}{GHGem_{REF}} \qquad \text{Eq. A 2.1.8}$$

with
GHGem: Greenhouse gas emission

$$GHGem = N_2O * 310 + CH_4 * 21 \qquad \text{Eq. A 2.1.9}$$

with
N_20: amount of stickoxide
CH_4: amount of Methane

$$N2O, CH4 = F(livstock, manure) \qquad \text{Eq. A 2.1.10}$$

with
livestock: livestock production process
manure: manure practice

Table 2.1-2: Coefficients for GHG calculation.

Calculation from GHG to CO_2 equivalents		
		CO_2 equivalents
	N_2O	310
	CH_4	21
Calculation from livestock to GHG		
	NH_4 from enteric fermentation	**NH_4 from manure management**
Dairy cow	118	14
Suckler cow	48	6
Bull	48	6
Heifer	48	6
Sow, fattening pig	1.5	3
sheep	8	0.19
horse	18	1.4
Chicken and poultry	--	0.078

Source: Donellan and Hanrahan, (2007: 81)

Weighted potential of nitrogen leaching and soil erosion

For the calculation of the weighted indicator values for nitrogen emission and soil erosion, it is assumed that in all counties intercrops reduce nitrogen emission and erosion by 40%. For simplification the impact of intercropping is related to the nitrogen emission and erosion potential of the entire UAA, although in practise it affects only the arable land.

$$\text{Weighted nitrogen input or erosion potential} = Eropot * 0.6 * \frac{incrops}{UAA_{REF}} \quad \text{Eq. A 2.1.11}$$

with
incrops: intercrops

Potential AEM area

Change in area under agri environmental measures (AEM) represent a measure for the spatial extension and reduction of AEM area. The unit for AEM area is percentage share of UAA (as it is also done in the case of production area for crops or grassland).

$$\text{Change of crop area} = \frac{AEM_{SCEN}}{UAA_{REF}} - \frac{AEM_{REF}}{UAA_{REF}} \quad \text{Eq. A 2.1.12}$$

with
AEM: potential area with agri-environmental programs

Table 2.1-3 presents six measures derived for potential AEM area (?) according to the agri-environmental program MEKA3. Due to the lack of data AEM activities are modelled in two different ways: (1) as 'real' activity in the optimization process and (2) as counted activity not implied in the optimization process. The modelling of the AEM in ACRE is described in detail in Section 3.5.

Table 2.1-3: Overview and description of the measures which are defined as potential AEM area.

Abbrev-iation	Description of the measure	Definition with respect to the activities
NA-2	Crop rotation with four crop groups	Four crop groups of the same share of area. Crop group 1: Winter cereals (winter wheat, winter barley, triticale) Crop group 2: Spring cereals (spring wheat, spring barley) Crop group 3: Root crops, vegetables and extensive cereals (sugar beet, potatoes, vegetables, rye, oat, clover.) Crop group 4: Oilseeds, legumes, maize, and set-aside (winter rapeseed, legumes, sunflowers, silage maize, grain maize, corn-cob-mix, set-aside)
NB-1	Cattle density is between 0.3 and 2.0 LU per hectares	Number of cattle per ha grassland area
NB-2	Cattle density is between 0.3 and 1.4 LU per hectares	Number of cattle per ha grassland area
NC-4	Regional typical pasture	Defined for the grassland used as meadows
NE-2	Greening of arable area in autumn	Defined for the area of winter wheat, legumes, winter barley, spring barley, oats, winter rapeseed, rye, triticale
NE-3	Greening of set-aside area	Defined for set-aside area

Change of pesticide application (not used in this study)

In order to provide information about the changes of environmental pollution by active substances from pesticides, the application of pesticides has been introduced as an indicator. The indicator value is the percentage change of the amount of the active substances (AS), which is calculated according to

$$\textit{Change of active substances} \quad = 1 - \frac{AS_{SCEN}}{AS_{REF}} \qquad \textit{Eq. A 2.1.13}$$

with
AS: amount of active substances

The amount of AS is derived from the amount of crop and specifict pesticide (PScrop) and from the content of AS amount within the pesticide (ASPS) multiplied by the crop acreage.

$$AS \quad = PC_{crop} * AS_{PS} * crop \qquad \textit{Eq. A 2.1.14}$$

with:PC_{crop}*: amount of pesticides applied for crop*
AS_{PS}*: amount of active substances in pesticide*
crop: crop acreage

The amount of applied pesticides is differentiated into intensive and extensive crop production intensities. The active substances derived out of 103 out of which 19 are mentioned in the analysis of the LUBW (2007) the "Grundwasserueberwachungsergebnisse 2007".

Table 2.1-4: Active substances calculated as indicator in ACRE.

Active Substance	Mentioned in LUBW 2007	Active Substance	Mentioned in LUBW 2007	Active Substance	Mentioned in LUBW 2007
Aclonifen		Fenpropidin		Natriumhydro	
alpha-Cyperm		Fenpropimorp		Natrium-Salz	
Aluminium-Sa		Florasulam		Nicosulfuron	
Amidosulfuro		Fluazinam		Octansaeuree	
Amitraz		Flufenacet	yes	Penconazol	yes
Amitrol		Flupyrsulfur		Pencycuron	
Azadirachtin		Fluroxypyr		Pendimethali	yes
Azoxystrobin		Flusilazol		Phenmedipham	yes
B-thuringens		Fosetyl		Pirimicarb	
B-th-500-var		Gyphosat	yes	Propargyl-2-	
Bentazon	yes	Imidacloprid		Propiconazol	yes
Bromoxynil		Indoxacarb		Propyzamid	
Carbendazim		Iodosulfuron		Prosulfocarb	
Carfentrazon		Ioxynil		Pymetrozin	
Chlorid		Iprodion		Quinmerac	
Chlormequat		Isopropylami		Quinoxyfen	

Active Substance	Mentioned in LUBW 2007	Active Substance	Mentioned in LUBW 2007	Active Substance	Mentioned in LUBW 2007
Chlorthaloni		Isoproturon	yes	Quizalofop-P	
Clodinafop		Kalium-Salz		Rapsoel	
Cloquintocet		Kresoxim-met		Rhizinusoel	
Cyfluthrin		Kupferoxid-c		Schwefel	
Cymoxanil		Kupferoxychl		Schwefel-80p	
Deiquat		lambda-Cyhal		Spiroxamine	
Desmedipham		1-Methyl-hep		Tebuconazole	
Dibromid		Mancozeb		Tebufenozid	
Dichlorprop-	yes	Maneb		Tolylfluanid	
Diethofencar		Marlopon-AT-		Trifloxystro	
Diethylester		MCPA	yes	Trinexapac	
Difenoconazo		Mecoprop-P	yes		
Diflufenican	yes	Mefenpyr			
Dimethoat	yes	Mesotrione			
Dimethomorph		Metaldehyd			
Dithianon		Metamitron	yes		
Diuron	yes	Metazachlor	yes		
Epoxiconazol	yes	Methanol-15p			
Esfenvalerat		Methylester-			
Ethephon		Metosulam			
Ethofumesat	yes	Metribuzin	yes		
Ethylester		Myclobutanil			

Source: own calculations based on following sources:
Data for applied pesticides retrieved researched in: LEL 2003, applied pesticides for arable crops; KTBL (1998): 41, (applied pesticides for wine); KTBL (2002): 93, applied pesticides for cabbage vegetable; Spiess-Urania Chemicals GmbH 2004: (applied pesticides for apple).
Data for active substances in the applied pesticides researched in: BVL (2004)
Diverse Product information of pesticide products not listed in BVL (2004)

2.2 Regional analysis framework for agricultural production in the study region

Table 2.2-1: Development of crop production in Baden-Wuerttemberg.

Crop production	Extent of production						Development in % relative to the year 1999		
	1979	**1991**	**1999**	**2003**	**2005**	**2007**	**2003**	**2005**	**2007**
Landuse	ha	ha	ha	ha	ha	ha	%	%	%
Utilized agricultural area	1503717	1448487	1473118	1452682	1446464	1435682		-2	-3
Arable land	830600	829170	849547	837323	836297	834535	-1	-2	-2
Grassland	628280	572087	573671	565085	560240	551397	-1	-2	-4
Fruit	17577	18094	21059	21491	21406	21343	2	2	1
Vine	20502	23477	23615	23987	23902	23923	2	1	1
Cerals and maize	577852	525373	538555	554600	n.d.	541019	3	n.d.	0
Legumes	4346	6691	8634	7236	n.d.	3942	-16	n.d.	-54
Root crops	70211	38177	32465	28746	n.d.	24942	-11	n.d.	-23
Horticultural crops	7912	8933	11798	12086	n.d.	13590	2	n.d.	15
Industrial crops	15366	86322	88270	76887	n.d.	77172	-13	n.d.	-13
out of these: oilseeds	11686	81838	83060	72072	n.d.	73112	-13	n.d.	-12
Foodder crops	152337	126373	120100	105162	n.d.	133926	-12	n.d.	12
Set-aside area	2576	36234	49726	52607	n.d.	39944	6	n.d.	-20
Extent of cultures	ha	ha	ha	ha	ha	ha	%	%	%
Wheat	217677	202528	210600	206420	n.d.	224636	-2	n.d.	7
Winter wheat	199210	195802	199151	192752	n.d.	219723	-3	n.d.	10
Rye	18239	15485	10510	6692	n.d.	9391	-36	n.d.	-11
Triticale	n.d.	2165	11569	15870	n.d.	19908	37	n.d.	72
Winter barley	56433	88057	96456	100842	n.d.	103911	5	n.d.	8
Spring barley	128691	109981	102538	100828	n.d.	83668	-2	n.d.	-18
Oats	92452	58948	40263	43951	n.d.	30074	9	n.d.	-25
Grain maize	28381	36779	59290	73735	n.d.	64874	24	n.d.	9
Silage maize	82598	78882	72666	68814	n.d.	89064	-5	n.d.	23
Potatoes	25097	9812	8073	6824	n.d.	5948	-15	n.d.	-26
Sugar beet	22493	23537	22730	20624	n.d.	18435	-9	n.d.	-19
Winter rapeseed	8801	65412	70423	67531	n.d.	70552	-4	n.d.	0

Table 2.2-2: Development of animal production in Baden-Wuerttemberg.

	Extent of production						Development in % relative to the year 1999		
Animal production									
	1979	**1991**	**1999**	**2003**	**2005**	**2007**	**2003**	**2005**	**2007**
Number of animals	heads	heads	heads	heads	heads	heads	%	%	%
Cattle number	1847039	1568941	1269310	1138310	n.d.	1030126	-10	n.d.	-19
Dairy cattle number	687269	569310	443141	398290	n.d.	362212	-10	n.d.	-18
Bulls number	n.d.	290369	190851	162114	n.d.	141829	-15	n.d.	-26
Pigs number	2118099	2197231	2320044	2302247	n.d.	2238322	-1	n.d.	-4
Breeding pigs number	276810	307546	324615	299859	n.d.	271854	-8	n.d.	-16
Animal density	heads ha^{-1}	heads ha^{-1}	heads ha^{-1}	heads ha^{-1}	heads ha^{-1}	heads ha^{-1}	%	%	%
Fattening pigs density	n.d.	43	42	45	n.d.	48	7	n.d.	14
Fattening pigs number	n.d.	618916	614005	652419	n.d.	686069	6	n.d.	12
Horses number	27343	36751	56949	64212	n.d.	67816	13	n.d.	19
Sheep number	159150	244871	294681	301212	n.d.	274311	2	n.d.	-7
Chicken number	5619376	4694967	4365939	4267128	n.d.	3815817	-2	n.d.	-13
Laying hens number	4090818	3323251	2835493	2662045	n.d.	2296618	-6	n.d.	-19
Cattle density	123	108	86	78	n.d.	72	-9	n.d.	-16
Dairy cattle density	46	39	30	27	n.d.	25	-10	n.d.	-17
Bulls density	n.d.	20	13	11	n.d.	10	-15	n.v.	-23
Pigs number density	141	152	157	158	n.d.	156	1	n.v.	-1
Breeding pigs density	18	21	22	21	n.d.	19	-5	n.v.	-14
Horse number density	2	3	4	4	n.d.	5	0	n.v.	+25
Sheep number density	11	17	20	21	n.d.	33	4	n.v.	64
Chicken density	374	324	296	294	n.d.	266	-1	n.v.	-10
Laying hens density	272	229	192	183	n.d.	424	-5	n.v.	121

Source: STALA BW (2009) Statistisches Landesamt Baden-Württemberg, Stuttgart, 2009. Regional Datenbank.
URL http://www.statistik.baden-wuerttemberg.de/SRDB/home.asp?H=Landwirtschaft [2009-08-08].

Table 2.2-3: Overview of NUTS3 counties and farm types.

NUTS3 county	Symbol	ID	Farm type	NUTS3 county	Symbol	ID	Farm type	NUTS3 county	Symbol	ID	Farm type
SK Stuttgart	S	8111	AL-CC	LK Rastatt	RA	8216	AL-CC	LK Konstanz	KN	8335	AL-FC
LK Boeblingen	BB	8115	AL-CC	SK Heidelberg	HDsk	8221	AL-CC	LK Loerrach	LOE	8336	GL-IG
LK Esslingen	ES	8116	GL-EG	SK Mannheim	MAsk	8222	AL-CC	LK Waldshut	WT	8337	GL-EG
LK Goeppingen	GP	8117	GL-FC	LK Neckar-Odenwald-Kreis	MOS	8225	AL-FC	LK Reutlingen	RT	8415	GL-EG
LK Ludwigsburg	LB	8118	AL-CC	LK Rhein-Neckar-Kreis	HD	8226	AL-CC	LK Tuebingen	TUE	8416	AL-CC
LK Rems-Murr-Kreis	WN	8119	GL-FC	SK Pforzheim	PFsk	8231	AL-CC	LK Zollernalbkreis	BL	8417	GL-EG
SK Heilbronn	HNsk	8121	AL-CC	LK Calw	CW	8235	GL-EG	SK Ulm	ULsk	8421	AL-FC
LK Heilbronn	HN	8125	AL-CC	LK Enzkreis	PF	8236	AL-CC	LK Alb-Donau-Kreis	UL	8425	AL-FC
LK Hohenlohekreis	KUEN	8126	AL-CC	LK Freudenstadt	FDS	8237	GL-EG	LK Biberach	BC	8426	AL-FC
LK Schwaebisch Hall	SHA	8127	AL-CC	SK Freiburg i.Breisgau	FRsk	8311	GL-IG	LK Bodenseekreis	FN	8435	AL-CC
LK Main-Tauber-Kreis	TBB	8128	AL-CC	LK Breisgau-Hochschwarzwald	FR	8315	GL-IG	LK Ravensburg	RV	8436	GL-FC
LK Heidenheim	HDH	8135	AL-FC	LK Emmendingen	EM	8316	GL-IG	LK Sigmaringen	SIG	8437	AL-FC
LK Ostalbkreis	AA	8136	GL-FC	LK Ortenaukreis	OG	8317	AL-CC				
SK Baden-Baden	BAD	8211	AL-CC	LK Rottweil	RW	8325	GL-EG				
SK Karlsruhe	KAsk	8212	AL-CC	LK Schwarzwald-Baar-Kreis	VS	8326	GL-EG				
LK Karlsruhe	KA	8215	AL-CC	LK Tuttlingen	TUT	8327	GL-EG				

Figure 2.2-1: Administrative regions (left) and NUTS2 districts of Baden-Wuerttemberg.

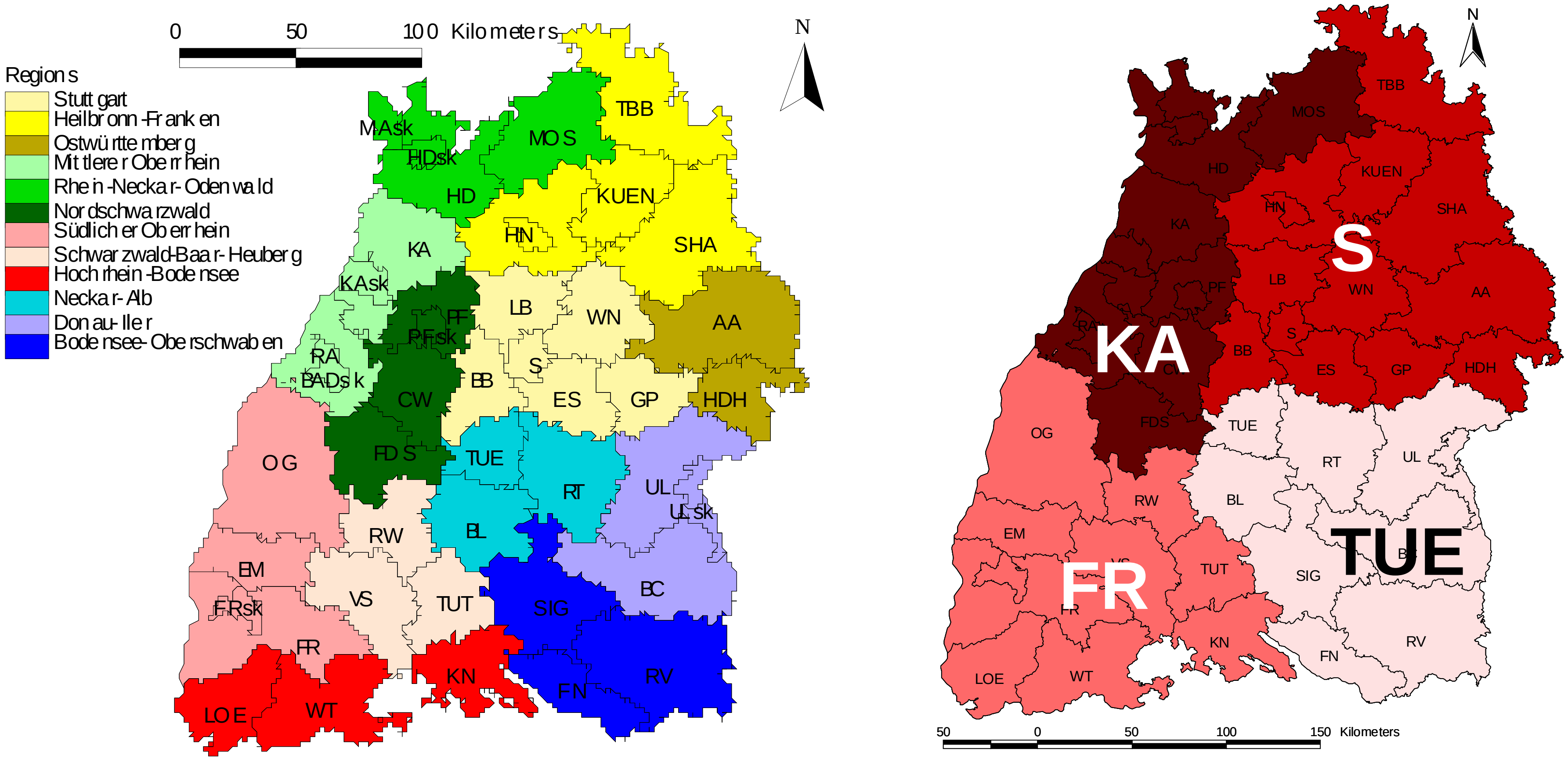
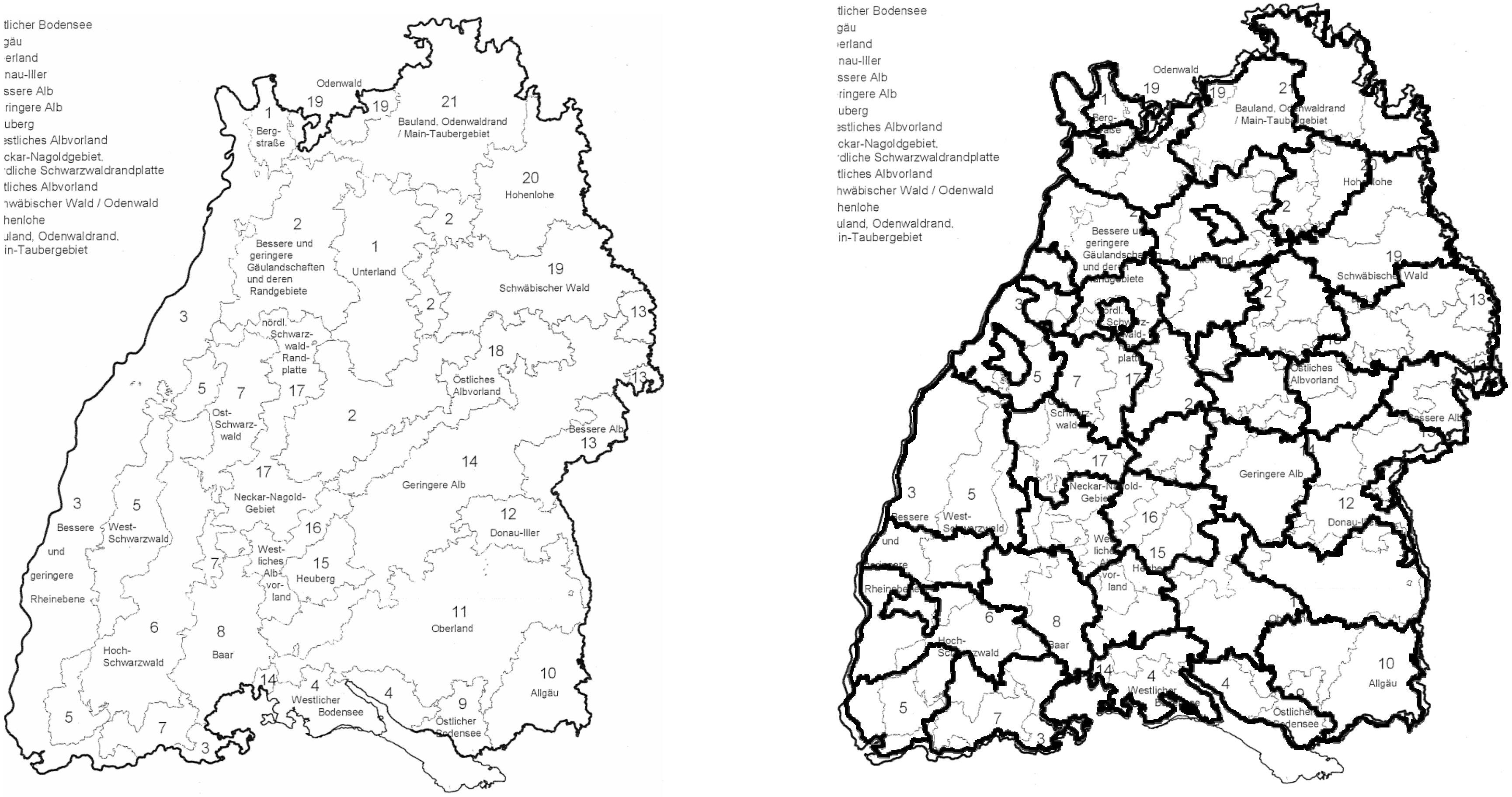


Figure 2.2-2: Natural regions (left) and NUTS3 regions mapped with natural regions (right) of Baden-Wuerttemberg.



2.3 The agricultural policy model ACRE

2.3.1 Characterization of APM: Examples of different APM

Table 2.3-1: Characterization and examples of different APM.

	Economic equilibrium	**Modelling approach and structure**	**Aggregation of results**	**Temporary resolution**
Attributes:	- general (CGE)a - partial sectoral (PE)b - supply	- econometric - programming - agent based	- multi-national - national - regional farm	- comparative static - recursive dynamic
Examples of APM				
GTAP	CGE	programming	multi-national	comparative static
AGLINK	PE	programming	multi-national	recursive dynamic
ESIM	PE	programming	national	comparative static
AGMEMOD	PE	strongly econometric based	national	recursive dynamic
CAPRI	PE	programming	regional	comparative static
FARMIS	supply	programming	farm	comparative static
AGRIPOLIS	supply	agent based	farm	recursive dynamic

Notes: a: CGE: Computable General Equilibrium. b: sectoral: representing the market with supply and demand, PE: partial equilibrium. c: also: normative, prescriptive, d: also: normative, prescriptive

References

GTAP (Global Trade Analysis Project): https://www.gtap.agecon.purdue.edu/ and http://www.vti.bund.de/no_cache/en/startseite/institutes/rural-studies/research-areas/policy-impact-assessment/vti-modelling-network/ [2011-01-13].

ESIM: European Simulation Model: Banse M. and Grethe H. (2008), European Simulation Model (ESIM) in GAMS: Model Documentation (Version 2.0) Model Documentation prepared for DG AGRI, European Commission, The Hague and Berlin, March, 2008.

AGMEMOD (Agri Food Projections for EU member states): http://www.tnet.teagasc.ie/agmemod/ and http://www.vti.bund.de/no_cache/en/startseite/institutes/rural-studies/research-areas/policy-impact-assessment/vti-modelling-network/ [2011-01-13].

FARMIS http://www.vti.bund.de/en/startseite/institutes/rural-studies/research-areas/policy-impact-assessment/vti-modelling-network/farmis.html. and http://www.vti.bund.de/no_cache/en/startseite/institutes/rural-studies/research-areas/policy-impact-assessment/vti-modelling-network [2011-01-13].

AGLINK-COSIMO (COSIMO = COmmodity SImulation MOdel): http://www.agri-outlook.org/pages/0,2987,en_36774715_36775671_1_1_1_1_1,00.html [2011-01-13].

CAPRI (Common Agricultural Policy Regional Impact Analysis): http://www.ilr1.uni-bonn.de/agpo/rsrch/capri/capri_e.htm and http://www.vti.bund.de/no_cache/en/startseite/institutes/rural-studies/research-areas/policy-impact-assessment/vti-modelling-network/ [2011-01-13].

AGRIPOLIS: Konrad K., Happe, K., Sahrbacher, C., Balmann, A., Brady, M., Hauke, S., Osuch, A., 2008. AgriPoliS 2.1 – Model documentation. URL: http://www.agripolis.de/documentation/agripolis_v2-1.pdf [2011-01-13].

2.3.2 Description and validation of the regional model RAUMIS: The vTI modelling framework

The framework includes different models to analyse at different scales: GTAP (Global Trade Analysis Project) to analyse the world market, AGMEMOD (Agri-food projection for EU member states) to analyse at member state level, CAPRI (Common Agricultural Policy Regionalised Impact Modelling) to analyse at regional level (NUTS2) in all European member states, RAUMIS to analyse at regional level (NUTS3) for Germany, and FARMIS

(Farm Modeling Information System) to analyse at farm scale in Germany (Offermann et al. 2010; vTI 2008).

As stand-alone model RAUMIS is used for policy analysis of CAP impacts. Furthermore RAUMIS is applied for economic and environmental analysis for the impacts of the Water Framework Directive, the Kyoto Protocol, renewable crop production as well as impacts of global change and climate change. In addition, RAUMIS provides input-output analysis for the environmental balances of the German national statistical office (Kreins et al. 2010, 2008, 2007; Gömann et al. 2009, 2008; vTI 2008).

RAUMIS has been used for example for following studies: Analyses of 1992 CAP-reform impacts, partial liberalization of CAP (sugar beet market, milk market), decoupling of subsidies (uniform subsidies for arable land and for the whole agricultural area; fully decoupled transfers), ban of chemical plant-protection, cost-benefit-analysis of different nitrate policies; impacts of agri-environmental programmes (example of North Rhine Westfalia); pesticide application scenarios (Kreins et al. 2010, 2008; Sieber et al. 2010; ILR 2010).

The institutions working with RAUMIS and RAUMIS model results are e.g.: BMELV (Federal Ministry of Food, Agriculture and Consumer Protection), Universitaet Bonn, Potsdam Institute for Climate Impact Research (PIK), Center for Environmental research (UFZ), Forschungszentrum Jülich GmbH (FZ-Jülich) ; Institut für Gewässerökologie und Binnenfischerei (IGB-Berlin) (Kreins et al. 2010; vTI 2008).

2.3.3 Aggregation of NUTS3 counties to NUTS2 districts in the model ACRE-SouthernGermany

Table 2.3-2: Names and aggregation of NUTS2 and NUTS3 regions and farm types in ACRE-SouthernGermany.

	NUTS3 counties (Lkr) aggregated with …		**… the NUTS3 city counties (Krfr. SK)**			**NUTS3 counties (Lkr) aggregated with …**	**SK_ABB**	**LK_ABB**		**… the NUTS3 city counties (Krfr. SK)**		**Farm type**
9171	Altötting				**8111**	Stuttgart (Krfr. St)	S	S				AL-CC
9172	Berchtesgadener Land				**8115**	Boebling	BB	BB				AL-CC
9173	Bad Tölz-Wolfratshausen				**8116**	Esslingen	ES	ES				AL-CC
9174	Dachau				**8117**	Goeppingen	GP	GP				GL-EG
9175	Ebersberg				**8118**	Ludwigsburg	LB	LB				GL-FC
9176	Eichstaett	**9161**	Ingolstadt		**8119**	Rems-Mur-Kreis	WN	WN				AL-CC
9177	Erding				**8125**	Heilbronn	HN	HN	**8121**	Heilbron	HNsk	GL-FC
9178	Freising				**8126**	Hohenlohe	KUEN	KUEN				AL-CC
9179	Fürstenfeldbruck				**8127**	Schwaebisch Gmuend	SHA	SHA				AL-CC
9180	Garmisch-Partenkirchen				**8128**	Main-Tauber-Kreis	TBB	TBB				AL-CC
9181	Landsberg am Lech				**8135**	Heidenheim	HDH	HDH				AL-CC
9182	Muenchen	**9162**	Muenchen		**8136**	Ostalbkreis	AA	AA				AL-FC
9183	Mühldorf a.Inn				**8215**	Karlsruhe	KA	KA	**8212**	Karlsruhe	KAsk	GL-FC
9184	München								**8211**	Baden-Baden	BAD	AL-CC
9185	Neuburg-Schrobenhausen				**8216**	Rastatt	RA	RA				AL-CC
9186	Pfaffenhofen a.d.Ilm				**8225**	Neckar-Odenwald-Kreis	MOS	MOS				AL-CC
9187	Rosenheim	**9163**	Rosenheim		**8226**	Rhein-Neckar Kreis	HD	HD	**8221**	Heidelberg	HDsk	AL-FC
9188	Starnberg								**8222**	Mannheim	MAsk	AL-CC
9189	Traunstein				**8235**	Calw	CW	CW				AL-CC
9190	Weilheim-Schongau				**8236**	Enzkreis	PF	PF	**8231**	Pforzheim	PFsk	GL-EG
9271	Deggendorf				**8237**	Freudenstadt	FDS	FDS				AL-CC
9272	Freyung-Grafenau				**8315**	Breisgau	FR	FR	**8311**	Freiburg	FRsk	GL-EG
9273	Kelheim				**8316**	Emmendingen	EM	EM				GL-IG
9274	Landshut	**9261**	Landshut		**8317**	Ortenaukreis	OG	OG				GL-IG

	NUTS3 counties (Lkr) aggregated with …		… the NUTS3 city counties (Krfr. SK)			NUTS3 counties (Lkr) aggregated with …	SK_ABB	LK_ABB		… the NUTS3 city counties (Krfr. SK)		Farm type
9275	Passau	**9262**	Passau		**8325**	Rottweil	RW	RW				AL-CC
9276	Regen				**8326**	Schwarzwald-Baar-Kreis	VS	VS				GL-EG
9277	Rottal-Inn				**8327**	Tuttlingen	TUT	TUT				GL-EG
9278	Straubing-Bogen	**9263**	Straubing		**8335**	Konstanz	KN	KN				GL-EG
9279	Dingolfing-Landau				**8336**	Loerrach	LOE	LOE				AL-FC
9371	Amberg-Sulzbach	**9361**	Amberg		**8337**	Waldshut	WT	WT				GL-IG
9372	Cham				**8415**	Reutlingen	RT	RT				GL-FC
9373	Neumarkt i.d.OPf.				**8416**	Tuebingen	TUE	TUE				GL-EG
9374	Neustadt a.d.Waldnaab	**9363**	Weiden i.d.OPf.		**8417**	Zollernalbkreis	BL	BL				AL-CC
9375	Regensburg	**9362**	Regensburg		**8425**	Alb-Donau-Kreis	UL	UL	**8421**	Ulm	ULsk	GL-EG
9376	Schwandorf				**8426**	Biberach	BC	BC				AL-FC
9377	Tirschenreuth				**8435**	Bodensee-kreis	FN	FN				AL-FC
9471	Bamberg	**9461**	Bamberg		**8436**	Ravensburg	RV	RV				AL-CC
9472	Bayreuth	**9462**	Bayreuth		**8437**	Sigmaringen	SIG	SIG				GL-FC
9473	Coburg	**9463**	Coburg									AL-FC
9474	Forchheim					**NUTS2 districts**						
9475	Hof	**9464**	Hof		**8001**	Stuttgart						
9476	Kronach				**8002**	Karlsruhe						
9477	Kulmbach				**8003**	Freiburg						
9478	Lichtenfels				**8004**	Tuebingen						
9479	Wunsiedel i.Fichtelgebirge				**9100**	Oberbayern						
9571	Ansbach	**9561**	Ansbach		**9200**	Niederbayern						
9572	Erlangen-Hoechstadt	**9562**	Erlangen		**9300**	Oberpfalz						
9573	Fuerth	**9563**	Fuerth		**9400**	Oberfranken						
9574	Nuernberger Land	**9564**	Nuernberg		**9500**	Mittelfranken						
9575	Neustadt a.d.Aisch-Bad Windsheim				**9600**	Unterfranken						
9576	Roth	**9565**	Schwabach		**9700**	Schwaben						
9577	Weißenburg-Gunzenhausen											
9671	Aschaffenburg	**9661**	Aschaffenburg			**Federal states**						

	NUTS3 counties (Lkr) aggregated with …		… the NUTS3 city counties (Krfr. SK)			NUTS3 counties (Lkr) aggregated with …	SK_ABB	LK_ABB		… the NUTS3 city counties (Krfr. SK)		Farm type
9672	Bad Kissingen				**8000**	Baden-Wuerttemberg	BW					
9673	Rhön-Grabfeld				**9000**	Bavaria	BY					
9674	Haßberge											
9675	Kitzingen					**Model region**						
9676	Miltenberg					Southern Germany	SG					
9677	Main-Spessart											
9678	Schweinfurt	**9662**	Schweinfurt									
9679	Wuerzburg	**9663**	Wuerzburg									
9771	Aichach-Friedberg											
9772	Augsburg	**9761**	Augsburg									
9773	Dillingen a.d.Donau											
9774	Günzburg											
9775	Neu-Ulm											
9776	Lindau (Bodensee)											
9777	Ostallgaeu	**9762**	Kaufbeuren									
9778	Unterallgaeu	**9764**	Memmingen									
		9763	Kempten (Allgaeu)									
9779	Donau-Ries											
9780	Oberallgäu											

2.3.4 Regional results of the ex-post analysis and the analysis of the aggregation error

Table 2.3-3: Results of the ex-post analysis for model regions and NUTS3 counties.

	WADcrop																					WADregion					
	ACRE-SG						ACRE-BW							ACRE-BY								ACRE-SG		ACRE-BW		ACRE-BY	
Region	Grassland	Cereals	Oilseeds&legumes	Root crops	Fodder crops	Special crops	Region	Grassland	Cereals	Oilseeds&legumes	Root crops	Fodder crops	Special crops	Region	Grassland	Cereals	Oilseeds&legumes	Root crops	Fodder crops	Special crops							
SG	1.24	2.44	1.40	0.49	2.46	0.48	**BW**	1.35	1.72	1.44	0.48	2.10	0.32	**BY**	1.19	2.36	1.43	0.50	2.46	0.56	**SG**	8.51	**BW**	7.42	**BY**	8.49
8111	2.60	1.39	0.99	1.18	1.53	2.55	**8111**	2.59	1.46	0.98	1.18	1.62	2.56								**8111**	10.23	**8111**	10.39		
8115	1.14	4.51	2.76	0.75	1.39	0.04	**8115**	1.15	2.55	2.97	0.74	0.79	0.04								**8115**	10.57	**8115**	8.24		
8116	0.39	0.67	0.53	0.41	1.22	1.38	**8116**	0.40	0.41	0.54	0.41	1.50	1.38								**8116**	4.60	**8116**	4.64		
8117	1.26	1.50	1.01	0.22	0.98	0.05	**8117**	1.25	2.53	1.10	0.22	2.10	0.05								**8117**	5.03	**8117**	7.25		
8118	1.51	0.75	3.20	2.50	1.66	0.19	**8118**	1.51	4.75	3.06	2.50	2.49	0.19								**8118**	9.81	**8118**	14.49		
8119	0.44	2.26	1.33	0.71	2.97	0.53	**8119**	0.46	1.11	1.23	0.71	0.53	0.53								**8119**	8.24	**8119**	4.56		
8125	1.02	0.87	3.87	2.98	2.44	0.34	**8125**	1.02	0.92	3.88	2.98	2.49	0.34								**8125**	11.53	**8125**	11.64		
8126	0.54	1.28	2.18	0.47	2.03	0.41	**8126**	0.54	2.12	2.27	0.47	2.97	0.41								**8126**	6.91	**8126**	8.78		
8127	1.76	0.00	0.72	0.25	1.37	0.08	**8127**	1.74	3.83	1.24	0.25	3.01	0.08								**8127**	4.17	**8127**	10.14		
8128	0.19	3.52	3.75	0.42	0.04	0.04	**8128**	0.19	0.95	4.20	0.42	2.98	0.04								**8128**	7.95	**8128**	8.78		
8135	0.49	0.07	0.43	0.19	0.12	0.06	**8135**	0.50	1.32	0.27	0.19	1.30	0.06								**8135**	1.34	**8135**	3.63		
8136	1.27	1.69	0.63	0.19	2.50	0.03	**8136**	1.26	0.64	0.89	0.19	0.11	0.03								**8136**	6.31	**8136**	3.12		
8215	2.87	6.44	3.56	2.20	1.19	1.02	**8215**	3.12	1.59	3.83	2.11	4.31	1.06								**8215**	17.26	**8215**	16.02		
8216	3.26	3.91	0.07	0.44	1.03	0.01	**8216**	3.22	3.91	0.07	0.44	1.07	0.01								**8216**	8.71	**8216**	8.71		
8225	1.57	0.43	1.71	0.65	3.17	0.11	**8225**	1.56	0.50	1.55	0.65	2.08	0.11								**8225**	7.64	**8225**	6.45		
8226	1.35	4.52	2.90	1.16	0.76	0.67	**8226**	1.35	0.55	3.11	1.16	3.43	0.67								**8226**	11.36	**8226**	10.27		
8235	0.22	1.41	1.39	0.35	0.12	0.03	**8235**	0.23	0.32	1.50	0.35	1.09	0.03								**8235**	3.53	**8235**	3.52		
8236	2.96	1.68	1.47	0.47	2.29	0.01	**8236**	2.96	1.67	1.47	0.47	2.31	0.01								**8236**	8.89	**8236**	8.89		

	WADcrop																					WADregion					
	ACRE-SG						ACRE-BW							ACRE-BY								ACRE-SG		ACRE-BW		ACRE-BY	
Region	**Grassland**	**Cereals**	**Oilseeds&legumes**	**Root crops**	**Fodder crops**	**Special crops**	**Region**	**Grassland**	**Cereals**	**Oilseeds&legumes**	**Root crops**	**Fodder crops**	**Special crops**	**Region**	**Grassland**	**Cereals**	**Oilseeds&legumes**	**Root crops**	**Fodder crops**	**Special crops**						
8237	2.51	3.28	0.24	0.16	0.88	0.19	**8237**	2.51	3.32	0.23	0.16	0.93	0.19								**8237**	7.25	**8237**	7.33		
8315	0.33	2.31	1.20	0.22	0.26	1.40	**8315**	0.32	1.88	1.21	0.22	0.19	1.40								**8315**	5.71	**8315**	5.21		
8316	0.80	2.72	0.35	0.24	0.80	1.00	**8316**	0.79	2.70	0.34	0.24	0.80	1.00								**8316**	5.92	**8316**	5.88		
8317	0.65	4.00	1.90	0.42	0.92	0.95	**8317**	0.66	0.22	1.94	0.42	2.91	0.95								**8317**	8.85	**8317**	7.11		
8325	0.59	1.52	0.63	0.20	1.72	0.04	**8325**	0.59	1.54	0.63	0.20	1.74	0.04								**8325**	4.69	**8325**	4.74		
8326	0.69	2.86	0.75	0.24	3.09	0.07	**8326**	0.71	1.36	0.50	0.24	1.32	0.07								**8326**	7.69	**8326**	4.19		
8327	1.00	3.82	1.56	0.03	4.43	0.02	**8327**	1.62	1.92	1.28	0.03	1.62	0.02								**8327**	10.85	**8327**	6.49		
8335	0.22	5.40	0.23	0.11	5.33	0.19	**8335**	0.86	5.67	0.93	0.10	7.62	0.25								**8335**	11.48	**8335**	15.43		
8336	0.91	0.86	0.28	0.27	0.50	0.44	**8336**	0.91	0.86	0.28	0.27	0.50	0.44								**8336**	3.26	**8336**	3.26		
8337	0.36	3.20	1.13	0.22	2.01	0.08	**8337**	0.37	1.77	1.20	0.22	0.51	0.08								**8337**	7.01	**8337**	4.16		
8415	0.11	1.64	0.15	0.24	1.64	0.02	**8415**	0.11	1.62	0.15	0.24	1.62	0.02								**8415**	3.79	**8415**	3.75		
8416	1.39	3.78	0.90	0.02	6.01	0.03	**8416**	1.17	1.87	0.60	0.04	3.57	0.04								**8416**	12.13	**8416**	7.29		
8417	5.51	6.72	1.84	0.18	3.22	0.00	**8417**	5.56	1.49	1.07	0.18	2.82	0.00								**8417**	17.46	**8417**	11.12		
8425	0.81	2.08	0.17	0.18	3.30	0.05	**8425**	0.80	0.35	0.19	0.17	0.49	0.05								**8425**	6.60	**8425**	2.06		
8426	1.55	3.95	0.30	0.14	5.32	0.01	**8426**	1.52	2.14	1.11	0.14	1.60	0.01								**8426**	11.28	**8426**	6.53		
8435	3.45	4.31	3.31	0.01	1.89	2.56	**8435**	3.49	1.66	3.53	0.01	0.93	2.54								**8435**	15.53	**8435**	12.14		
8436	2.91	1.65	0.39	0.00	4.03	0.13	**8436**	2.88	0.23	0.57	0.00	1.94	0.13								**8436**	9.11	**8436**	5.76		
8437	0.89	4.32	0.01	0.29	5.45	0.04	**8437**	0.89	4.32	0.01	0.29	5.45	0.04								**8437**	11.01	**8437**	11.01		
9171	3.08	1.82	1.27	0.15	3.93	0.15								**9171**	3.08	1.55	1.30	0.15	3.62	0.15	**9171**	10.39			**9171**	9.85
9172	2.28	0.66	0.00	0.01	1.74	0.11								**9172**	2.28	0.67	0.00	0.01	1.73	0.11	**9172**	4.81			**9172**	4.79
9173	0.73	0.50	0.32	0.01	0.08	0.17								**9173**	0.75	0.50	0.32	0.01	0.09	0.17	**9173**	1.81			**9173**	1.85
9174	0.26	5.71	2.19	1.18	3.17	0.57								**9174**	0.26	5.71	2.19	1.18	3.17	0.57	**9174**	13.08			**9174**	13.09
9175	2.44	0.03	0.01	1.16	4.45	0.89								**9175**	2.42	0.06	0.03	1.16	4.49	0.89	**9175**	8.98			**9175**	9.04
9176	0.44	2.13	2.84	0.06	0.06	0.26								**9176**	0.44	2.14	2.84	0.06	0.06	0.26	**9176**	5.80			**9176**	5.81
9177	1.34	1.96	1.89	0.08	1.94	0.61								**9177**	1.34	1.94	1.89	0.08	1.92	0.61	**9177**	7.81			**9177**	7.78

	WADcrop																				WADregion					
	ACRE-SG						ACRE-BW							ACRE-BY							ACRE-SG		ACRE-BW		ACRE-BY	
Region	**Grassland**	**Cereals**	**Oilseeds&legumes**	**Root crops**	**Fodder crops**	**Special crops**	**Region**	**Grassland**	**Cereals**	**Oilseeds&legumes**	**Root crops**	**Fodder crops**	**Special crops**	**Region**	**Grassland**	**Cereals**	**Oilseeds&legumes**	**Root crops**	**Fodder crops**	**Special crops**						
9178	0.70	2.69	2.74	0.30	1.36	0.42								**9178**	0.69	2.60	2.76	0.30	1.24	0.41	**9178**	8.20			**9178**	8.00
9179	0.14	4.75	2.27	0.23	2.46	0.35								**9179**	0.15	4.85	2.25	0.23	2.58	0.35	**9179**	10.21			**9179**	10.41
9180	0.33	0.19	0.00	0.00	0.09	0.00								**9180**	0.33	0.18	0.00	0.00	0.09	0.00	**9180**	0.61			**9180**	0.59
9181	1.17	2.53	1.22	0.44	3.40	0.48								**9181**	1.17	2.53	1.22	0.44	3.40	0.48	**9181**	9.24			**9181**	9.24
9182	0.78	0.84	0.04	0.00	0.04	0.06								**9182**	0.83	0.86	0.04	0.00	0.07	0.06	**9182**	1.76			**9182**	1.87
9183	0.59	1.25	0.99	0.10	0.15	0.09								**9183**	0.59	1.26	0.99	0.10	0.14	0.09	**9183**	3.16			**9183**	3.16
9184	0.56	0.73	0.25	2.45	2.43	1.02								**9184**	0.56	0.73	0.25	2.45	2.43	1.02	**9184**	7.44			**9184**	7.45
9185	0.21	0.56	1.53	1.46	1.82	1.53								**9185**	0.21	0.57	1.53	1.46	1.82	1.53	**9185**	7.12			**9185**	7.13
9186	0.55	2.92	1.40	0.02	1.11	0.13								**9186**	0.55	2.92	1.40	0.02	1.11	0.13	**9186**	6.12			**9186**	6.13
9187	1.96	0.80	0.09	0.04	3.52	0.64								**9187**	1.96	0.80	0.09	0.04	3.52	0.64	**9187**	7.05			**9187**	7.05
9188	1.43	2.35	0.15	1.10	2.36	0.49								**9188**	1.43	2.34	0.15	1.10	2.35	0.49	**9188**	7.88			**9188**	7.85
9189	1.71	1.22	0.59	0.03	3.59	0.10								**9189**	1.71	1.22	0.59	0.03	3.59	0.10	**9189**	7.24			**9189**	7.24
9190	0.30	0.08	0.00	0.03	0.41	0.05								**9190**	0.30	0.09	0.00	0.03	0.41	0.05	**9190**	0.86			**9190**	0.86
9271	1.36	1.74	1.60	0.20	1.01	2.42								**9271**	1.36	1.74	1.60	0.20	1.00	2.42	**9271**	8.32			**9271**	8.31
9272	0.90	0.26	0.03	0.12	0.50	0.05								**9272**	0.86	0.25	0.03	0.12	0.47	0.05	**9272**	1.87			**9272**	1.78
9273	0.29	3.57	1.10	0.00	2.08	0.10								**9273**	0.29	3.56	1.11	0.00	2.07	0.10	**9273**	7.14			**9273**	7.12
9274	0.54	1.93	2.71	0.46	0.29	0.07								**9274**	0.54	1.91	2.72	0.46	0.27	0.07	**9274**	6.01			**9274**	5.97
9275	1.40	1.19	1.18	0.08	1.87	0.38								**9275**	1.40	1.19	1.18	0.08	1.87	0.38	**9275**	6.10			**9275**	6.10
9276	0.44	0.47	0.00	0.00	0.08	0.00								**9276**	0.44	0.53	0.00	0.00	0.02	0.00	**9276**	0.98			**9276**	0.98
9277	1.01	4.16	2.06	0.07	3.42	0.24								**9277**	1.01	4.02	2.07	0.07	3.27	0.24	**9277**	10.96			**9277**	10.69
9278	0.45	1.30	1.57	2.37	1.49	1.54								**9278**	0.45	1.63	1.59	2.37	1.14	1.54	**9278**	8.73			**9278**	8.72
9279	1.20	3.66	2.98	1.08	5.21	4.66								**9279**	1.20	3.66	2.98	1.08	5.21	4.66	**9279**	18.78			**9279**	18.78
9371	2.52	1.95	0.54	0.30	1.55	0.15								**9371**	2.52	1.94	0.54	0.30	1.57	0.15	**9371**	7.01			**9371**	7.01
9372	0.69	0.48	0.75	0.65	1.18	0.11								**9372**	0.60	0.57	0.75	0.65	1.17	0.11	**9372**	3.86			**9372**	3.84
9373	1.25	0.28	0.85	0.30	0.46	0.03								**9373**	1.25	0.29	0.84	0.30	0.45	0.03	**9373**	3.17			**9373**	3.17

	WADcrop																				WADregion					
	ACRE-SG						ACRE-BW							ACRE-BY							ACRE-SG		ACRE-BW		ACRE-BY	
Region	Grassland	Cereals	Oilseeds&legumes	Root crops	Fodder crops	Special crops	Region	Grassland	Cereals	Oilseeds&legumes	Root crops	Fodder crops	Special crops	Region	Grassland	Cereals	Oilseeds&legumes	Root crops	Fodder crops	Special crops						
9374	1.15	1.07	0.33	0.75	3.41	0.11								**9374**	0.95	0.24	0.18	0.74	2.22	0.11	**9374**	6.83			**9374**	4.44
9375	0.47	1.41	2.04	0.68	0.03	0.40								**9375**	0.47	1.40	2.04	0.68	0.03	0.40	**9375**	5.03			**9375**	5.03
9376	0.23	0.04	0.14	1.15	1.36	0.15								**9376**	0.23	0.04	0.14	1.15	1.36	0.15	**9376**	3.08			**9376**	3.08
9377	0.17	0.02	1.43	0.35	1.76	0.14								**9377**	0.07	0.10	1.38	0.35	1.70	0.14	**9377**	3.85			**9377**	3.74
9471	0.43	2.19	0.18	0.45	3.41	0.51								**9471**	0.54	2.10	0.22	0.46	3.40	0.52	**9471**	7.18			**9471**	7.25
9472	0.29	1.67	1.55	0.58	3.61	0.10								**9472**	0.29	1.67	1.55	0.58	3.61	0.10	**9472**	7.79			**9472**	7.79
9473	1.52	0.85	0.52	0.69	2.68	0.15								**9473**	1.52	0.86	0.52	0.69	2.70	0.15	**9473**	6.41			**9473**	6.43
9474	2.06	4.05	0.82	0.72	5.25	3.36								**9474**	2.06	4.06	0.82	0.72	5.26	3.36	**9474**	16.27			**9474**	16.28
9475	1.13	2.73	0.82	0.84	0.09	0.03								**9475**	1.13	2.75	0.81	0.84	0.06	0.03	**9475**	5.64			**9475**	5.62
9476	0.17	0.59	0.28	0.34	0.73	0.25								**9476**	0.17	0.56	0.28	0.34	0.70	0.25	**9476**	2.36			**9476**	2.31
9477	0.49	0.44	0.38	0.20	0.82	0.20								**9477**	0.49	0.44	0.38	0.20	0.82	0.20	**9477**	2.53			**9477**	2.53
9478	1.33	2.29	2.17	0.31	3.91	0.47								**9478**	1.33	2.29	2.17	0.31	3.91	0.47	**9478**	10.48			**9478**	10.48
9479	0.35	0.59	0.95	1.14	3.23	0.21								**9479**	0.35	0.61	0.95	1.14	3.25	0.21	**9479**	6.46			**9479**	6.51
9571	2.53	2.11	0.21	0.51	5.65	0.29								**9571**	2.51	2.18	0.19	0.51	5.68	0.29	**9571**	11.30			**9571**	11.37
9572	0.19	1.00	1.74	0.73	2.10	1.91								**9572**	0.19	0.98	1.74	0.73	2.07	1.91	**9572**	7.67			**9572**	7.62
9573	1.01	0.11	2.77	2.14	0.05	1.49								**9573**	1.01	0.11	2.78	2.14	0.05	1.49	**9573**	7.57			**9573**	7.58
9574	4.20	3.44	0.60	0.56	2.29	3.08								**9574**	4.19	3.44	0.59	0.56	2.30	3.08	**9574**	14.17			**9574**	14.17
9575	0.22	0.73	1.12	1.01	1.03	0.18								**9575**	0.22	0.73	1.12	1.01	1.03	0.18	**9575**	4.29			**9575**	4.29
9576	0.38	3.12	1.77	1.52	3.30	0.81								**9576**	0.38	3.12	1.77	1.52	3.30	0.81	**9576**	10.91			**9576**	10.91
9577	0.10	3.65	0.45	0.25	3.82	0.27								**9577**	0.10	3.84	0.42	0.25	4.05	0.27	**9577**	8.54			**9577**	8.93
9671	4.58	9.51	1.40	0.37	5.29	1.39								**9671**	4.58	9.51	1.40	0.37	5.29	1.39	**9671**	22.52			**9671**	22.52
9672	0.26	7.27	3.97	0.23	3.58	0.32								**9672**	0.26	7.26	3.97	0.23	3.58	0.32	**9672**	15.64			**9672**	15.63
9673	1.08	8.05	4.22	0.73	3.62	0.13								**9673**	1.09	7.93	4.25	0.72	3.45	0.13	**9673**	17.82			**9673**	17.56
9674	1.15	5.10	4.35	0.36	2.66	0.40								**9674**	1.15	5.10	4.35	0.36	2.66	0.40	**9674**	14.03			**9674**	14.03
9675	0.23	3.76	4.80	1.50	2.62	1.93								**9675**	0.23	3.76	4.80	1.50	2.62	1.93	**9675**	14.85			**9675**	14.85

	WADcrop																				WADregion					
	ACRE-SG						ACRE-BW							ACRE-BY							ACRE-SG		ACRE-BW		ACRE-BY	
Region	**Grassland**	**Cereals**	**Oilseeds&legumes**	**Root crops**	**Fodder crops**	**Special crops**	**Region**	**Grassland**	**Cereals**	**Oilseeds&legumes**	**Root crops**	**Fodder crops**	**Special crops**	**Region**	**Grassland**	**Cereals**	**Oilseeds&legumes**	**Root crops**	**Fodder crops**	**Special crops**						
9676	3.36	12.70	2.04	0.23	7.54	0.01								**9676**	3.36	12.70	2.04	0.23	7.54	0.01	**9676**	25.88			**9676**	25.88
9677	1.34	10.00	4.67	0.28	4.71	0.45								**9677**	1.24	9.92	4.73	0.30	4.71	0.45	**9677**	21.45			**9677**	21.36
9678	1.13	7.50	5.42	0.92	3.02	1.15								**9678**	1.13	7.50	5.42	0.92	3.02	1.15	**9678**	19.14			**9678**	19.14
9679	0.24	5.54	3.58	0.37	3.25	1.15								**9679**	0.24	5.54	3.58	0.37	3.25	1.15	**9679**	14.13			**9679**	14.13
9771	1.51	1.62	0.98	0.24	2.94	0.54								**9771**	1.51	1.59	0.98	0.24	2.90	0.54	**9771**	7.83			**9771**	7.76
9772	2.92	1.69	2.58	0.51	3.32	0.78								**9772**	2.92	2.04	2.54	0.51	3.71	0.78	**9772**	11.80			**9772**	12.50
9773	1.39	4.31	1.56	0.62	5.91	1.14								**9773**	1.39	4.32	1.56	0.62	5.91	1.14	**9773**	14.94			**9773**	14.94
9774	2.75	2.15	1.95	0.18	3.44	0.30								**9774**	2.75	2.12	1.95	0.18	3.40	0.30	**9774**	10.77			**9774**	10.71
9775	1.30	3.12	1.69	0.50	3.27	0.04								**9775**	1.30	3.12	1.69	0.50	3.27	0.04	**9775**	9.92			**9775**	9.92
9776	0.06	0.00	0.00	0.00	0.12	0.05								**9776**	0.06	0.00	0.00	0.00	0.12	0.05	**9776**	0.24			**9776**	0.24
9777	3.18	1.93	0.30	0.01	1.59	0.03								**9777**	3.12	1.94	0.30	0.01	1.53	0.03	**9777**	7.05			**9777**	6.93
9778	5.01	0.57	0.28	0.03	4.21	0.07								**9778**	5.01	0.54	0.27	0.03	4.23	0.07	**9778**	10.17			**9778**	10.17
9779	0.83	5.78	1.07	0.66	7.26	1.06								**9779**	0.83	5.78	1.07	0.66	7.26	1.06	**9779**	16.66			**9779**	16.66
9780	0.04	0.00	0.00	0.00	0.00	0.04								**9780**	0.04	0.00	0.00	0.00	0.00	0.04	**9780**	0.08			**9780**	0.08

Table 2.3-4: Results of the ex-post analysis for model regions and NUTS2 districts.

WADcrop																					WADregion					
ACRE-SG							ACRE-BW							ACRE-BY							ACRE-SG		ACRE-BW		ACRE-BY	
	Grassland	Cereals	Oilseeds and legumes	Root crops	Fodder crops	Special crops	Region	Grassland	Cereals	Oilseeds and legumes	Root crops	Fodder crops	Special crops	Region	Grassland	Cereals	Oilseeds and legumes	Root crops	Fodder crops	Special crops						
SG	0.92	2.00	1.21	0.46	2.60	0.47	**BW**	0.90	1.69	1.41	0.47	2.35	0.23	**BY**	0.95	2.33	1.19	0.46	3.06	0.57	**SG**	7.66	**BW**	7.04	**BY**	8.56
8001	0.28	0.81	2.10	0.79	1.84	0.01	**8001**	0.27	1.41	2.16	0.79	2.50	0.01								**8001**	5.83	**8001**	7.14		
8002	2.15	1.85	2.05	0.88	1.73	0.27	**8002**	2.14	2.00	2.04	0.88	1.57	0.27								**8002**	8.93	**8002**	8.90		
8003	0.29	2.13	0.44	0.24	1.14	0.49	**8003**	0.52	3.87	0.91	0.23	5.57	0.51								**8003**	4.73	**8003**	11.60		
8004	1.30	0.91	0.54	0.12	1.54	0.25	**8004**	1.29	0.27	0.69	0.12	0.21	0.25								**8004**	4.66	**8004**	2.82		
9100	0.72	3.10	0.72	0.22	3.78	0.45								**9100**	0.72	3.11	0.72	0.22	3.78	0.45	**9100**	8.99			**9100**	9.00
9200	0.22	1.84	1.76	0.48	1.80	1.01								**9200**	0.22	1.84	1.76	0.48	1.80	1.01	**9200**	7.12			**9200**	7.12
9300	0.62	0.23	0.25	0.67	1.43	0.17								**9300**	0.62	0.23	0.25	0.67	1.43	0.17	**9300**	3.37			**9300**	3.37
9400	0.32	0.57	0.60	0.60	2.60	0.52								**9400**	0.32	0.57	0.60	0.60	2.60	0.52	**9400**	5.20			**9400**	5.20
9500	0.65	1.85	0.63	0.80	3.40	0.73								**9500**	0.66	1.82	0.62	0.80	3.39	0.73	**9500**	8.06			**9500**	8.02
9600	0.79	7.48	4.11	0.63	4.00	0.78								**9600**	0.79	7.48	4.11	0.63	4.00	0.78	**9600**	17.80			**9600**	17.80
9700	2.92	1.24	0.87	0.21	3.93	0.43								**9700**	2.92	1.24	0.87	0.21	3.93	0.43	**9700**	9.60			**9700**	9.60

3 Scenario simulation

3.1 Reference year and baseline scenario

The regional results of the scenario calculation are listed in Appendix Chapter 5.

3.1.1 Development of agricultural production

In order to validate the results of the agricultural production indicators the tendency of changes of crop and bulls production are compared with the simulated developments of these indicators in eight other studies (summarized and compared in Balkhausen et al., 2007. The APM used in the other studies are general or partial equilibrium models, and the results published in Balkhausen et al. (2007) represent the impacts of decoupled direct payments of the CAP 2003 reform on agricultural production in the EU15.

The region EU15 is an aggregate of the EU member states before to the 2004 enlargement of the EU. As policy implementations and agricultural production is diverse within the EU15, a comparison between the results of the other studies with results for the ACRE model region Baden-Wuerttemberg can only be done by comparing the tendency of indicator value development.

Table 3.1-17 presents a comparison of the development of supply indicator values as calculated for this study with the development tendency of the same indicator values as calculated by other APM for EU15. It can be seen that for five supply indicators (beef, set-aside, fodder/clover, silage maize, oilseeds) the development tendencies calculated by ACRE matches the tendencies of the indicator value development in the other APM studies.

On the other hand, the development tendencies of cereals and pasture area are different in this study than in the other APM. Since cereal production is an important agricultural production this difference is relevant, and may be explained by different model formulations, differences in policy assumptions or different price assumptions (e.g. the development of the cereals price might be assumed to be higher in this study then in the other APM studies[1]).

[1] Indeed in the CGE and PE models the prices are a model result of the calculation. In ACRE the price is an endogenous parameter.

Table 3.1-1: Tendency of simulated agricultural production development in ACRE and other APM.

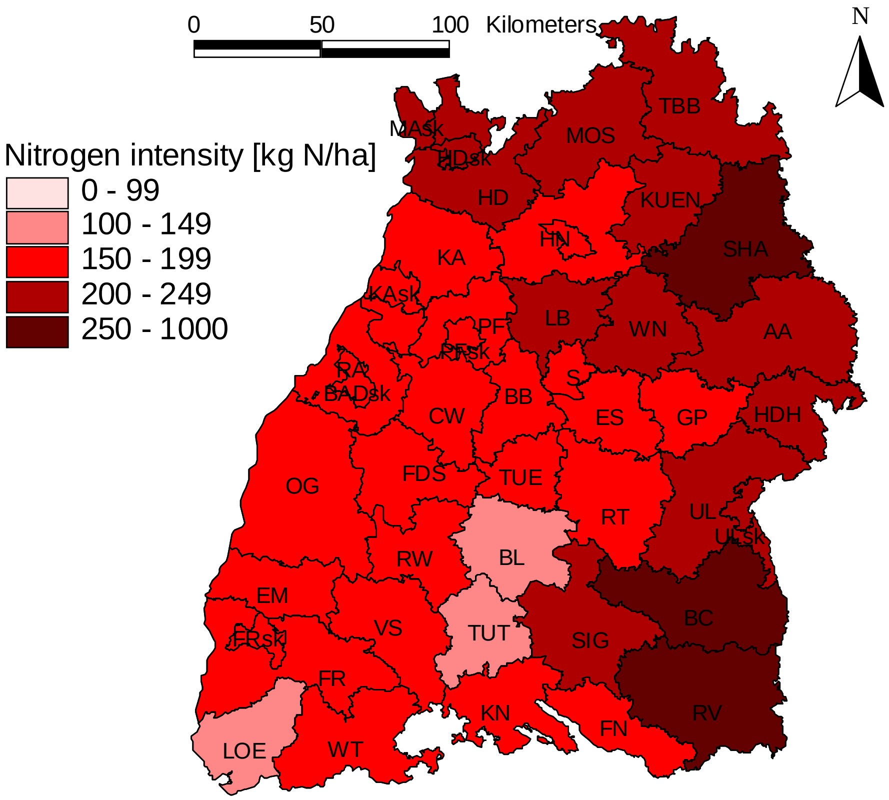
	Economic equilibrium	Model region	Cereals	Oilseeds	Pasture	Silage maize	Fodder/clover[a]	Set-aside	Beef
ACRE	Partial equilibrium (supply model)	BW	+	-	0	-	+	-	-
AGLINK	Partial equilibrium	EU15	-	0	X	X	X	X	-
AGMEMOD	Partial equilibrium	EU15	-	-	X	X	X	X	-
CAPRI	Programming and partial equilibrium	EU15	-	-	-	-	+	-	-
CAPSIM	Partial equilibrium	EU15	-	-	-	-	+	X	-
ESIM	Partial equilibrium	EU15	-	-	+	-	+	-	-
FAPRI	Partial equilibrium	EU15	-	-	X	X	X	X	-
GOAL	General equilibrium	EU15	-	X	-	X	+	X	-
GTAP	General equilibrium	EU15	-	-	X	X	X	X	-

+: increasing tendency, -: decreasing tendency, 0: no change; X: no info, a) in ACRE clover, in other models other fodder area than silage maize

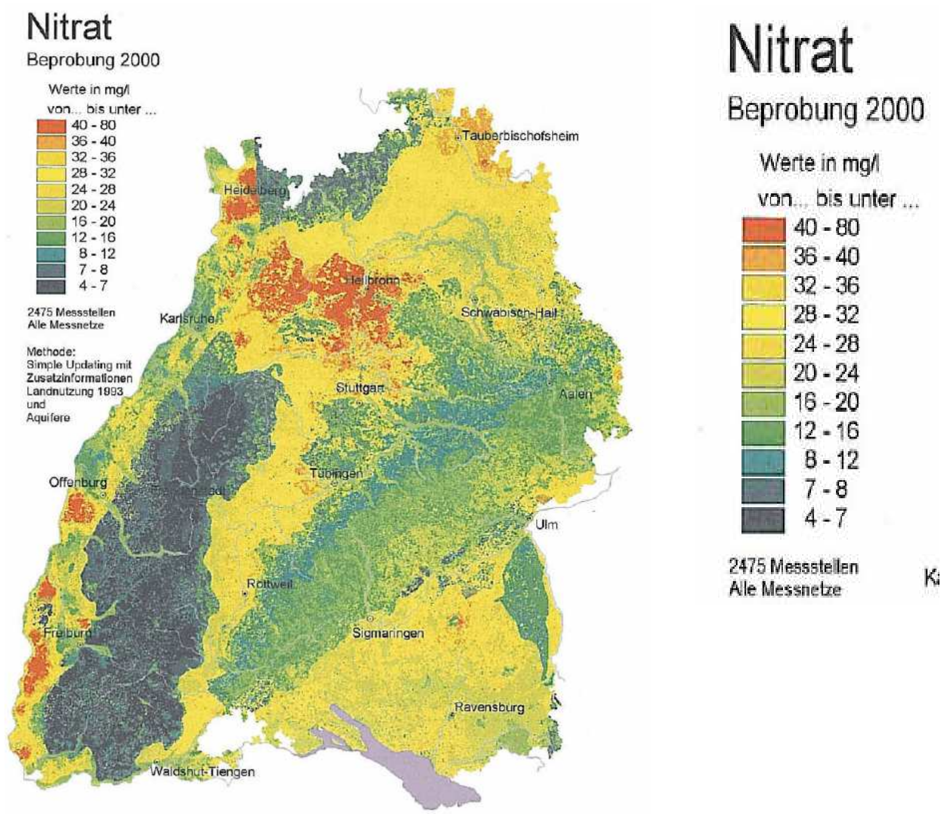
3.2 Figures of Section 3.5: regional nitrogen and nitrate intensity

Figure 3.2-1: Regional nitrogen and nitrate intensity measured or simulated in the years 2000, 2007 and 2015.

Nitrogen intensity in ACRE simulation REF 2000



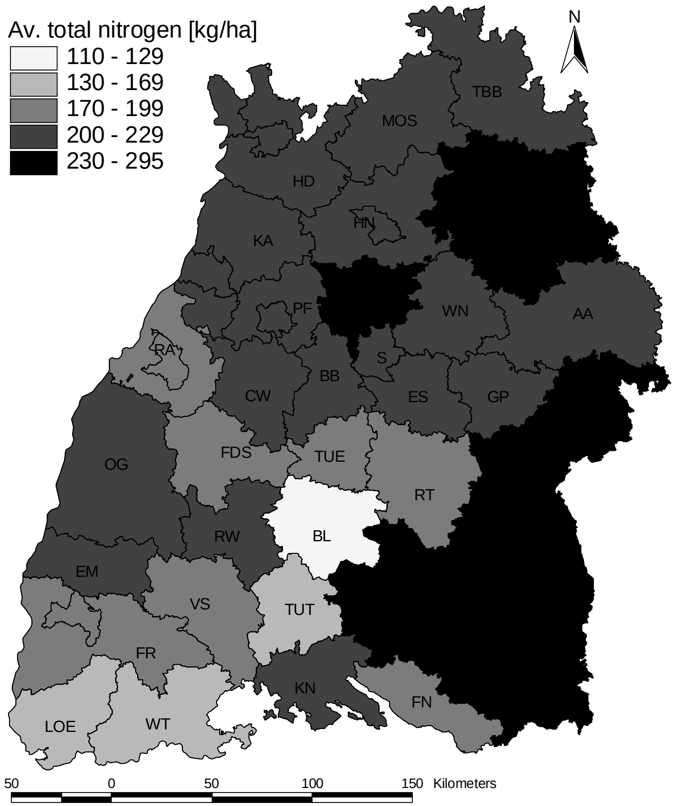
Nitrate intensity in ground water in measures of 2000



Notes: Unit: kg N ha^{-1}

Source: LfU 2000: Grundwasserüberwachungsprogramm 2000: Ergebnisse der Beprobung 2000.

Nitrogen intensity in ACRE simulation CAP 2015



Notes: Unit: kg N ha^{-1}

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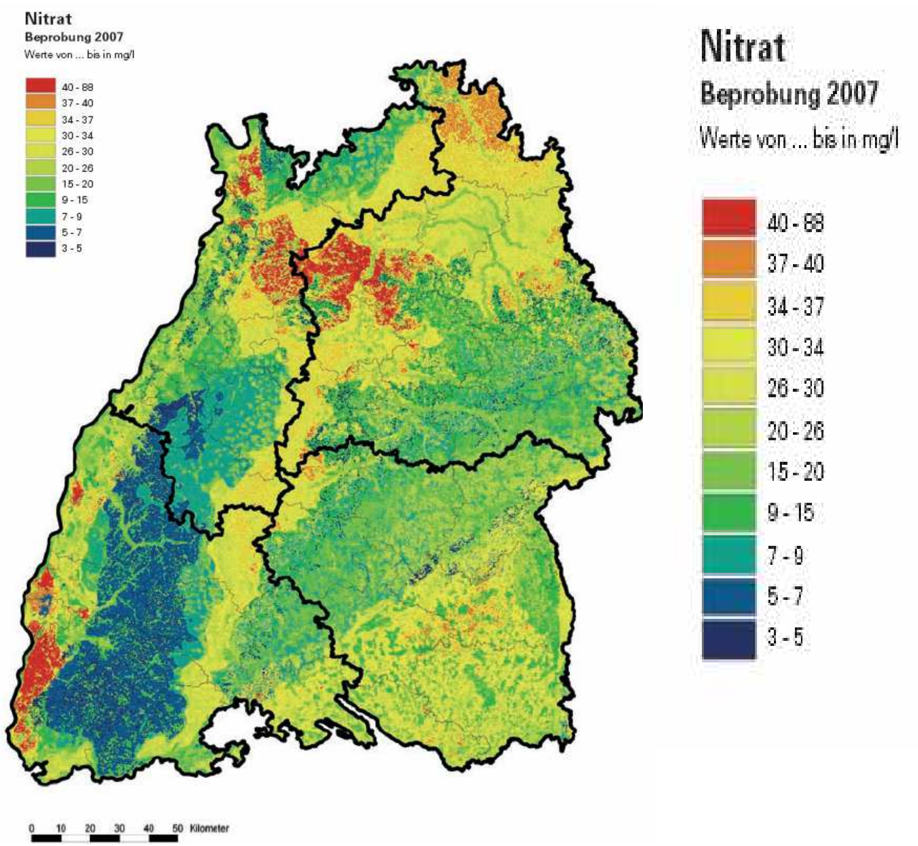
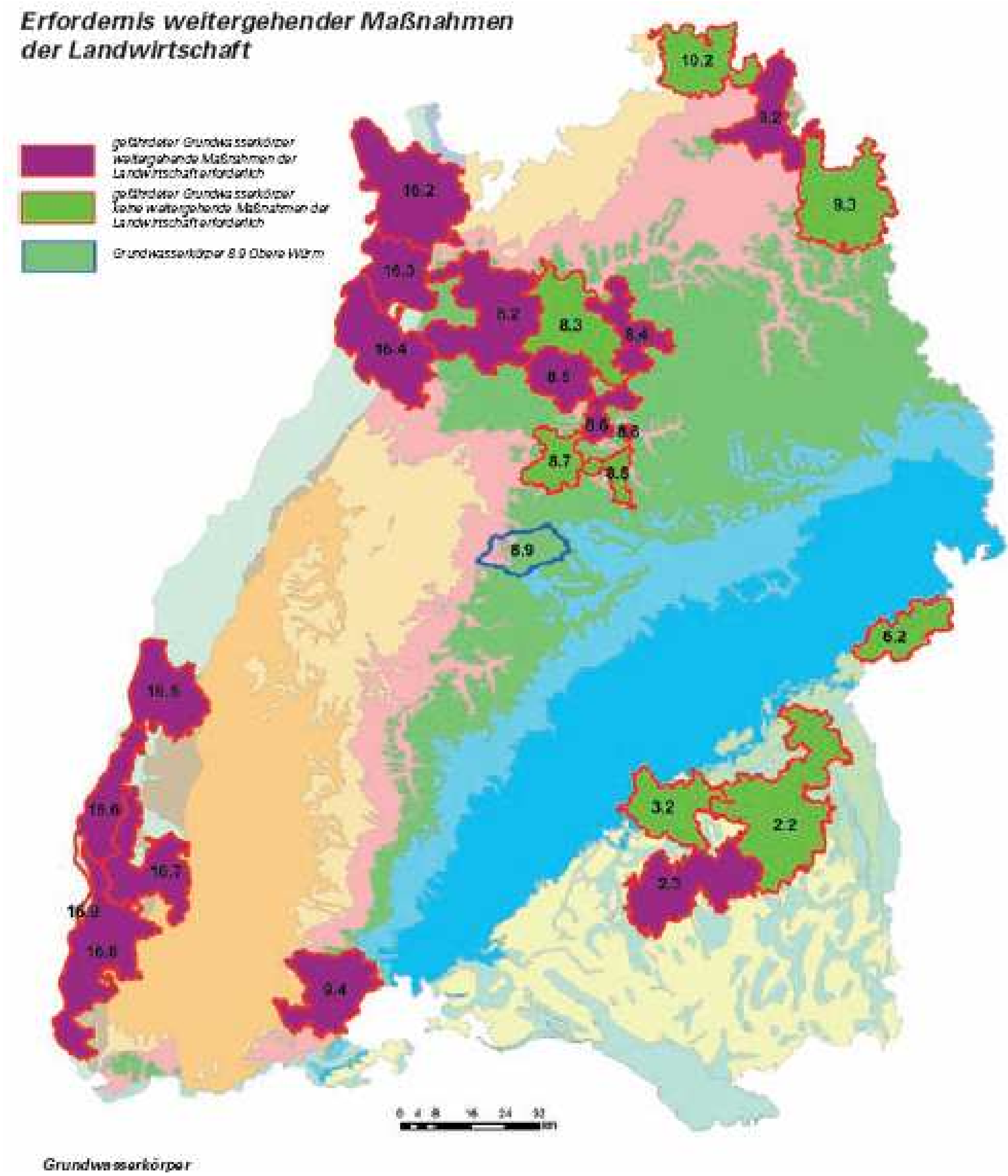
Nitrate intensity in measures of 2007



Source: LfU-BW 2008: Grundwasserüberwachungsprogramm 2007: Ergebnisse der Beprobung 2007.

Figure 3.2-2: Problematic zones with need of measures to reduce nitrogen input.



Notes: The dark zones indicate the problematic zones with need of measures to reduce the nitrogen input. Source: LfU-BW 2008.

4 Conclusion and discussion

4.1 Figures of regional nitrogen and nitrate intensity

Table 4.1-1: Comparison of ACRE-Danubia and ACRE-Southern Germany.

	ACRE-Danubia	**ACRE- Southern Germany**
Economic equilibrium	supply model	
Modelling approach		
- Model category	normative, programming model, optimisation model with non-linear objective function	
- Modelling approach	PMP developed by Roehm and Dabbert (2003): simulate production activities	
	process analytical approach	
	regional farm approach (NUTS3)	regional farm approach (NUTS3 and NUTS2)
Technical structure		
- Model structure	one model file and input output data	
- Programming language	GAMS	
Activities		
- Main production activities	several crop and animal production plus intensities	added: wine, energy maize
	Intensities implemented in calibration, derived from production conditions	
- other activities/indicators	several economic, supply and environmental indicators	added: abandoned UAA, erosion potential, potential AEM area
- Policies/instruments	Direct payments from Pillar 1 and Pillar 2 (partially), no observation of livestock density, standard management requirements: elements of CCP, agricultural and environmental standards: nutrition according to WFD	
- Reforms	Mac Sharry reform, Agenda 2000	Agenda 2000, updated: CAP 2003 reform

	ACRE-Danubia	ACRE- Southern Germany
Aggregation of results		
- Regional coverage	Danube river basin	Southern Germany
	10 NUTS3 in BW 47 NUTS3 in BY 16 NUTS3 in AT	4 NUTS2 in BW, 7 NUTS2 in BY 36 NUTS3 in BW 71 NUTS3 in BY farm types (5) analysis
Data		
- Model input data	regional statistics, empirical surveys (for production intensities), not regularly updated data base	
- Model output data	economic, production, and environmental indicators	
- temporary dimension	shortest period: 1 year, dynamic: comparative static	
	base year: 1995	base year: 2000
	simulation period calculated: 4 years	simulation period calculated: 15 years
Validation		
- Ex-post validations	Ex-post analysis from 1995 to 1999 (for BY)	from 2000 to 2007 (for BY)
- Analysis of the error of aggregation		Added: Analysis of the error of aggregation
Applications		
- economic model frameworks	no participation in economic model frameworks	
- interdisciplinary model frameworks	GLOWA-Danubia	RIVERTWIN-Neckar
- stand alone studies	sensitivity analysis for water prices, scenarios of decoupled of direct payments, scenarios of prices and subsidies of the year 2002, price scenarios for wheat, scenarios for restricted water reduction, climate change scenarios, global change scenarios	subsidy reduction scenarios, energy crop scenario, nitrogen reduction scenario, mandatory AEM scenario, combined scenario
Administration/scientific output		
- Development period	estimated 2001 to 2003	2004 to 2008
- Institutions	Universitaet Hohenheim, Institut for Farm Management	
- Maintenance	project depending	

	ACRE-Danubia	**ACRE- Southern Germany**
- Availability	Source code at Universitaet Hohenheim, ownership rights unclear, by BMBF project and EU FP 7 framework project	
- Scientific publications	3 doctoral thesis: Roehm 2001 (model approach), Winter (2005), Wirsig (2009), >10 reports, 2 scientific papers	1 doctoral thesis (work at hand)
- Scientific innovations during model history	PMP variant activity approach (Roehm and Dabbert 2003)	

5 Results data of scenario simulation

5.1 Scenario results in NUTS3 counties

Table 5.1-1: Status of economic, production and environmental indicator values in NUTS3 regions in the reference year (results from Section 3.1).

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
Unit: status/ difference	EUR ha^{-1}/%	EUR ha^{-1}/%	EUR ha^{-1}/%	EUR ha^{-1}/%	EUR ha^{-1}/%	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	%UAA/pp[o]	# ha^{-1} /% [t]	# ha^{-1} /% [t]	# ha^{-1} /% [t]	kg ha^{-1}/ %	kg ha^{-1}/ %	kg ha^{-1}/ %	kg ha^{-1}/ %	%pot/%[v]	%pot/%[v]	kg ha^{-1}/%	%UAA/pp[o]
S	216	179	53	2138	1922	33	5	6	37	6	4	2	0	0	13	7	0	0	20	3	33	72	48	178	178	54	138	11	1333	126
BB	310	253	81	1187	878	46	1	6	18	5	9	3	0	0	13	16	0	0	22	4	205	59	41	192	192	61	129	7	1505	158
ES	273	191	111	1249	976	29	2	7	15	2	4	3	0	0	19	27	0	0	27	8	113	42	38	196	196	87	114	6	1659	108
GP	268	166	138	1511	1243	26	0	11	7	0	4	1	0	0	14	42	0	0	55	11	161	31	21	199	199	109	89	4	2624	128
LB	288	257	46	1839	1551	44	5	9	27	11	5	3	0	0	12	4	0	0	25	8	279	75	68	225	225	66	158	10	1790	145
WN	255	167	119	1852	1597	25	3	10	14	2	2	2	0	0	15	34	0	0	46	11	165	38	25	201	201	107	99	6	2312	110
HNsk	263	239	36	1864	1601	43	4	5	37	14	5	4	0	0	9	3	0	0	16	4	143	80	65	197	197	45	154	11	1286	140
HN	263	239	36	1864	1601	43	4	5	37	14	5	4	0	0	9	3	0	0	16	4	143	80	65	197	197	45	154	11	1286	140
KUEN	300	252	69	2091	1791	44	3	8	21	5	8	4	0	0	8	15	0	0	30	7	519	63	26	247	247	109	136	8	2015	93
SHA	307	235	101	2039	1732	42	1	9	12	1	9	2	0	0	7	29	0	0	45	10	574	50	14	250	250	127	115	7	2591	117
TBB	349	316	53	1231	882	55	0	7	25	3	14	6	0	0	4	8	0	0	20	6	212	75	25	202	202	61	143	8	1443	94
HDH	313	243	98	1429	1116	41	0	12	12	1	9	1	0	0	7	28	0	0	45	10	332	53	18	220	220	95	119	6	2330	179
AA	291	200	123	1670	1379	31	0	12	8	1	6	2	0	0	9	39	0	0	59	14	188	41	14	206	206	108	94	6	2749	126
BAD	309	259	68	1209	900	23	25	2	22	1	4	8	0	0	8	19	0	0	9	3	137	56	16	165	165	38	128	11	975	79
KAsk	331	296	50	1003	672	43	13	4	25	5	8	7	0	0	6	10	0	0	9	3	85	66	56	177	177	29	146	10	986	161
KA	331	296	50	1003	672	43	13	4	25	5	8	7	0	0	6	10	0	0	9	3	85	66	56	177	177	29	146	10	986	161
RA	309	259	68	1209	900	23	25	2	22	1	4	8	0	0	8	19	0	0	9	3	137	56	16	165	165	38	128	11	975	79
HDsk	317	283	50	1356	1039	42	8	8	24	7	6	6	0	0	14	3	0	0	19	7	177	69	70	204	204	55	147	10	1456	151
MAsk	317	283	50	1356	1039	42	8	8	24	7	6	6	0	0	14	3	0	0	19	7	177	69	70	204	204	55	147	10	1456	151
MOS	334	284	72	1178	844	45	1	10	21	2	12	7	0	0	8	16	0	0	31	8	166	61	26	203	203	70	130	7	1792	102
HD	317	283	50	1356	1039	42	8	8	24	7	6	6	0	0	14	3	0	0	19	7	177	69	70	204	204	55	147	10	1456	151

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
Unit: status/ difference	**EUR ha^{-1}/%**	**EUR ha^{-1}/%**	**EUR ha^{-1}/%**	**EUR ha^{-1}/%**	**EUR ha^{-1}/%**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**%UAA/pp[o]**	**# ha^{-1} /%[t]**	**# ha^{-1} /%[t]**	**# ha^{-1} /%[t]**	**kg ha^{-1}/ %**	**kg ha^{-1}/ %**	**kg ha^{-1}/ %**	**kg ha^{-1}/ %**	**%pot/%[v]**	**%pot/%[v]**	**kg ha^{-1}/%**	**%UAA/pp[o]**
PFsk	312	249	89	1060	748	37	3	9	16	2	9	4	0	0	19	16	0	0	27	7	85	51	49	189	189	59	126	7	1631	162
CW	287	190	131	1111	824	30	0	8	10	1	5	4	0	0	12	40	0	0	38	7	102	33	18	177	177	86	89	4	1907	179
PF	312	249	89	1060	748	37	3	9	16	2	9	4	0	0	19	16	0	0	27	7	85	51	49	189	189	59	126	7	1631	162
FDS	289	196	127	1070	781	32	0	7	12	0	8	4	0	0	11	38	0	0	35	8	124	35	18	176	176	83	93	4	1784	181
FRsk	235	157	105	1672	1437	11	16	3	21	2	2	3	0	0	31	18	0	0	24	5	67	45	36	151	151	68	93	8	1372	81
FR	235	157	105	1672	1437	11	16	3	21	2	2	3	0	0	31	18	0	0	24	5	67	45	36	151	151	68	93	8	1372	81
EM	269	198	95	1868	1599	11	23	4	18	1	0	4	0	0	26	19	0	0	20	11	148	48	40	187	187	77	118	10	1654	78
OG	278	209	92	1860	1582	14	22	4	19	1	2	5	0	0	16	24	0	0	20	8	135	51	32	186	186	71	121	9	1510	84
RW	297	210	120	1134	837	35	0	7	13	0	10	2	0	0	10	35	0	0	35	9	232	41	14	188	188	87	102	4	1914	127
VS	261	151	147	1165	905	24	0	5	10	1	7	3	0	0	15	45	0	0	46	7	126	28	16	169	169	93	79	3	2163	139
TUT	262	147	153	1000	737	24	0	5	9	0	6	4	0	0	6	56	0	0	34	7	97	27	7	139	139	76	66	3	1656	188
KN	297	224	100	1504	1207	31	3	10	16	1	7	4	0	0	13	26	0	0	30	9	179	50	26	193	193	82	112	7	1854	105
LOE	242	143	133	1371	1128	12	10	5	10	0	1	2	0	0	41	22	0	0	22	8	83	31	51	145	145	71	77	5	1492	100
WT	267	160	145	1223	956	21	1	12	7	0	4	2	0	0	16	43	0	0	30	11	105	28	19	155	155	85	71	4	1893	167
RT	277	176	136	1161	884	29	0	9	9	1	4	3	0	0	8	45	0	0	36	8	125	32	10	171	171	91	81	4	1829	181
TUE	308	244	90	914	606	42	2	5	19	2	11	5	0	0	10	22	0	0	16	5	147	52	36	171	171	49	121	6	1211	111
BL	264	154	146	761	497	25	0	3	11	0	6	4	0	0	13	47	0	0	19	4	81	26	16	119	119	56	65	3	1095	130
ULsk	325	270	80	1666	1341	48	1	10	14	1	11	2	0	0	6	20	0	0	38	8	520	62	20	238	238	102	133	7	2326	106
UL	325	270	80	1666	1341	48	1	10	14	1	11	2	0	0	6	20	0	0	38	8	520	62	20	238	238	102	133	7	2326	106

Unit: status/ difference	SUBvol[m] EUR ha^{-1}/%	SUBvol[m] Pillar 1 EUR ha^{-1}/%	SUBvol[m] Pillar 2 EUR ha^{-1}/%	TGM[n] incl. SUB EUR ha^{-1}/%	TGM[n] excl. SUB EUR ha^{-1}/%	Cereals %UAA/pp[o]	Maize %UAA/pp[o]	Fodder crops %UAA/pp[o]	Others[p] %UAA/pp[o]	Root crops %UAA/pp[o]	Oil seeds and legumes %UAA/pp[o]	Set-aside area %UAA/pp[o]	Conv. of grassland[q] %UAA/pp[o]	Conv. of arable land[r] %UAA/pp[o]	Intensive grassland %UAA/pp[o]	Extensive grassland %UAA/pp[o]	Abandoned UAA[s] %UAA/pp[o]	Intensive crop area %UAA/pp[o]	Intensive variant area %UAA/pp[o]	Dairy cows # ha^{-1} /% [t]	Bulls # ha^{-1} /% [t]	Fattening pigs # ha^{-1} /% [t]	Nitrogen total kg ha^{-1}/ %	Nitrogen total (weight.)[u] kg ha^{-1}/ %	Nitrogen organic kg ha^{-1}/ %	Nitrogen demand kg ha^{-1}/ %	Erosion potential %pot/%[v]	Erosion pot. (weight.)[u] %pot/%[v]	GHG[w] emissions kg ha^{-1}/%	Potential AEM area[x] %UAA/pp[o]
BC	317	249	95	2178	1861	37	1	16	11	1	8	2	0	0	9	26	0	0	53	14	368	53	22	272	272	136	131	7	2943	107
FN	230	160	95	2821	2591	17	5	8	31	1	7	2	0	0	14	26	0	0	40	6	199	53	23	186	186	108	102	7	1982	85
RV	219	103	156	2208	1989	12	1	10	5	0	2	1	0	0	43	29	0	0	89	6	115	22	47	255	255	151	102	3	3655	116
SIG	306	232	103	1611	1305	39	1	10	13	1	9	3	0	0	7	30	0	0	30	8	375	49	12	221	221	103	117	6	1985	118

m: Subsidy. n: Total gross margin. o: Percent share of utilized agricultural area/percentage points of utilized agricultural area compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare. t: u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. vu: Percentage points difference from reference year. wv: Green house gas. xw: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. n.c.: not calculated.

Table 5.1-2: Status of potential AEM area in NUTS3 regions in the reference year (results from Section 3.1).

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
S	108	43	13	7	0	36	2	7	0	0	0	0	0	0
BB	142	54	0	16	16	54	3	0	0	0	0	0	0	0
ES	138	29	19	27	27	31	3	0	0	0	0	0	0	0
GP	151	23	14	42	42	30	1	0	0	0	0	0	0	0
LB	125	57	12	4	4	44	3	0	0	0	0	0	0	0
WN	130	19	15	34	34	25	2	0	0	0	0	0	0	0
HNsk	121	58	9	3	3	44	4	0	0	0	0	0	0	0
HN	121	58	9	3	3	44	4	0	0	0	0	0	0	0
KUEN	113	20	8	15	15	50	4	0	0	0	0	0	0	0
SHA	131	14	7	29	29	49	2	0	0	0	0	0	0	0
TBB	134	39	4	8	8	68	6	0	0	0	0	0	0	0
HDH	154	41	7	28	28	49	1	0	0	0	0	0	0	0
AA	146	20	9	39	39	37	2	0	0	0	0	0	0	0
BAD	100	21	8	19	19	25	8	0	0	0	0	0	0	0
KAsk	132	53	6	10	10	46	7	0	0	0	0	0	0	0
KA	132	53	6	10	10	46	7	0	0	0	0	0	0	0
RA	100	21	8	19	19	25	8	0	0	0	0	0	0	0
HDsk	126	55	14	3	3	44	6	0	0	0	0	0	0	0
MAsk	126	55	14	3	3	44	6	0	0	0	0	0	0	0
MOS	141	39	8	16	16	56	7	0	0	0	0	0	0	0
HD	126	55	14	3	3	44	6	0	0	0	0	0	0	0
PFsk	137	39	19	16	16	43	4	0	0	0	0	0	0	0
CW	167	37	12	40	40	35	4	0	0	0	0	0	0	0
PF	137	39	19	16	16	43	4	0	0	0	0	0	0	0
FDS	162	32	11	38	38	39	4	0	0	0	0	0	0	0
FRsk	95	14	31	18	18	12	3	0	0	0	0	0	0	0
FR	95	14	31	18	18	12	3	0	0	0	0	0	0	0
EM	86	9	26	19	19	11	4	0	0	0	0	0	0	0

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
OG	94	11	16	24	24	14	5	0	0	0	0	0	0	0
RW	157	30	10	35	35	45	2	0	0	0	0	0	0	0
VS	162	23	15	45	45	30	3	0	0	0	0	0	0	0
TUT	176	27	6	56	56	29	4	0	0	0	0	0	0	0
KN	134	29	13	26	26	35	4	0	0	0	0	0	0	0
LOE	105	5	41	22	22	12	2	0	0	0	0	0	0	0
WT	151	24	16	43	43	23	2	0	0	0	0	0	0	0
RT	173	39	8	45	45	33	3	0	0	0	0	0	0	0
TUE	149	37	10	22	22	51	5	0	0	0	0	0	0	0
BL	150	20	0	47	47	31	4	0	0	0	0	0	0	0
ULsk	145	39	6	20	20	59	2	0	0	0	0	0	0	0
UL	145	39	6	20	20	59	2	0	0	0	0	0	0	0
BC	129	22	9	26	26	44	2	0	0	0	0	0	0	0
FN	99	14	14	26	26	18	2	0	0	0	0	0	0	0
RV	121	6	43	29	29	13	1	0	0	0	0	0	0	0
SIG	146	28	7	30	30	47	3	0	0	0	0	0	0	0

%UAA: Percentage share of utilized agricultural area. pp: percentage points. NA-2: Crop rotation with four crop groups. NB-1: Cattle density is between 0.3 and 2.0 LU per hectares. NB-2: Cattle density is between 0.3 and 1.4 LU per hectares. NC-4: Regional typical pasture. NE-2: Greening of arable area in autumn. NE-3: Greening of set-aside area.

Table 5.1-3: Status of crop production area in NUTS3 regions in the reference year (results from Section 3.1).

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA
S	17	0	0	1	11	3	0	5	0	1	2	0	3	7	2	0	3	3	2	15	0	4	14	0	0	13	7	0
BB	21	1	0	5	15	5	0	1	0	1	1	0	3	1	7	1	2	4	3	21	0	1	0	0	0	13	16	0
ES	14	2	0	4	6	4	0	2	0	1	1	0	0	4	3	0	3	4	3	9	0	1	1	0	0	19	27	0
GP	9	1	1	6	5	5	0	0	0	1	0	0	0	0	4	0	5	6	1	7	0	0	0	0	0	14	42	0
LB	22	2	0	6	12	2	0	5	0	0	1	0	9	2	2	2	2	7	3	25	0	1	5	0	0	12	4	0
WN	9	1	0	5	4	5	0	3	0	0	1	0	1	2	1	0	4	6	2	9	0	2	4	0	0	15	34	0
HNsk	22	1	1	4	13	1	0	4	0	1	3	0	11	3	3	2	1	4	4	28	0	2	9	0	0	9	3	0
HN	22	1	1	4	13	1	0	4	0	1	3	0	11	3	3	2	1	4	4	28	0	2	9	0	0	9	3	0
KUEN	19	1	0	14	4	6	0	3	0	1	0	0	5	1	7	0	2	6	4	12	0	2	2	0	0	8	15	0
SHA	15	1	1	15	3	8	0	1	0	1	0	0	1	0	8	0	3	6	2	11	0	0	0	0	0	7	29	0
TBB	20	1	1	9	21	3	0	0	0	1	0	0	3	0	13	1	2	5	6	22	0	0	1	0	0	4	8	0
HDH	18	1	1	8	9	4	0	0	0	2	1	0	1	0	7	0	5	7	1	18	0	0	0	0	0	7	28	0
AA	12	0	0	9	5	5	0	0	0	1	0	0	0	0	5	0	3	9	2	9	0	0	0	0	0	9	39	0
BAD	9	1	4	2	4	3	0	25	0	1	1	0	0	3	2	1	1	1	8	14	0	3	2	0	0	8	19	0
KAsk	19	2	6	3	11	2	0	13	0	1	1	0	5	2	4	3	1	2	7	28	0	1	2	0	0	6	10	0
KA	19	2	6	3	11	2	0	13	0	1	1	0	5	2	4	3	1	2	7	28	0	1	2	0	0	6	10	0
RA	9	1	4	2	4	3	0	25	0	1	1	0	0	3	2	1	1	1	8	14	0	3	2	0	0	8	19	0
HDsk	20	2	2	5	12	2	0	8	0	0	1	0	7	2	3	3	2	6	6	25	0	1	1	0	0	14	3	0
MAsk	20	2	2	5	12	2	0	8	0	0	1	0	7	2	3	3	2	6	6	25	0	1	1	0	0	14	3	0
MOS	21	1	1	9	10	4	0	1	0	1	0	0	2	0	11	0	3	6	7	15	0	0	0	0	0	8	16	0
HD	20	2	2	5	12	2	0	8	0	0	1	0	7	2	3	3	2	6	6	25	0	1	1	0	0	14	3	0
PFsk	18	2	2	4	8	4	0	3	0	0	1	0	1	0	7	2	3	6	4	17	0	0	1	0	0	19	16	0
CW	11	0	1	3	9	6	0	0	0	1	1	0	0	0	5	0	5	3	4	12	0	0	0	0	0	12	40	0

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA
PF	18	2	2	4	8	4	0	3	0	0	1	0	1	0	7	2	3	6	4	17	0	0	1	0	0	19	16	0
FDS	13	0	1	5	8	6	0	0	0	0	0	0	0	0	7	0	5	2	4	9	0	0	0	0	0	11	38	0
FRsk	5	1	1	1	3	1	0	16	0	0	1	0	0	2	1	1	2	2	3	6	0	2	10	0	0	31	18	0
FR	5	1	1	1	3	1	0	16	0	0	1	0	0	2	1	1	2	2	3	6	0	2	10	0	0	31	18	0
EM	6	1	0	1	1	2	0	23	0	0	1	0	0	1	0	0	1	3	4	5	0	3	8	0	0	26	19	0
OG	8	1	0	2	2	1	0	22	0	0	1	0	0	1	0	2	1	3	5	9	0	7	4	0	0	16	24	0
RW	14	0	0	7	7	6	0	0	0	0	0	0	0	0	9	0	5	2	2	7	0	0	0	0	0	10	35	0
VS	9	0	1	5	5	4	0	0	0	1	1	0	0	0	6	0	3	2	3	3	0	0	0	0	0	15	45	0
TUT	8	0	0	5	7	4	0	0	0	0	0	0	0	0	5	0	3	2	4	3	0	0	0	0	0	6	56	0
KN	14	0	0	7	7	2	0	3	0	0	0	0	0	1	4	2	3	7	4	12	0	3	0	0	0	13	26	0
LOE	7	1	0	2	1	1	0	10	0	0	0	0	0	1	0	0	2	3	2	4	0	3	3	0	0	41	22	0
WT	8	0	0	4	6	3	0	1	0	0	0	0	0	0	2	2	7	5	2	7	0	0	0	0	0	16	43	0
RT	9	0	1	4	10	6	0	0	0	1	1	0	0	0	3	0	6	3	3	10	0	0	0	0	0	8	45	0
TUE	21	1	1	5	9	5	0	2	0	1	1	0	1	0	9	1	3	2	5	13	0	0	0	0	0	10	22	0
BL	10	0	1	3	5	6	0	0	0	1	0	0	0	0	6	0	2	1	4	3	0	0	0	0	0	13	47	0
ULsk	21	1	0	12	11	4	0	1	0	1	0	0	0	0	10	0	4	6	2	15	0	0	0	0	0	6	20	0
UL	21	1	0	12	11	4	0	1	0	1	0	0	0	0	10	0	4	6	2	15	0	0	0	0	0	6	20	0
BC	17	0	1	10	5	4	0	1	0	1	0	0	0	0	7	0	5	11	2	11	0	0	0	0	0	9	26	0
FN	8	1	0	4	2	1	0	5	0	0	0	0	0	2	2	4	3	6	2	7	0	18	1	0	0	14	26	0
RV	6	0	0	3	1	1	0	1	0	0	0	0	0	0	2	0	3	7	1	5	0	1	0	0	0	43	29	0
SIG	16	0	1	11	7	5	0	1	0	1	1	0	0	0	7	1	5	5	3	10	0	0	0	0	0	7	30	0

%UAA: Percent share of utilized agricultural area.

Table 5.1-4: Development of economic, production and environmental indicator values in NUTS3 regions in the scenario CAP2003 (results from Section 3.1).

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	% [t]	% [t]	% [t]	%	%	%	%	%[v]	%[v]	%	pp[o]
S	43	33	34	11	7	3	2	1	0	0	-2	-2	2	0	-1	-1	0	5	14	0	-3	-23	12	2	-8	19	3	-7	-1	6
BB	28	15	29	21	19	11	0	0	0	0	-6	-3	3	0	-1	-2	0	8	10	0	-5	-13	16	-3	-9	29	0	-17	4	-71
ES	45	55	-9	21	15	3	1	1	0	0	-2	-3	0	0	-3	3	0	2	-4	0	-4	-14	7	-3	-8	19	1	-9	-3	52
GP	55	83	-18	15	6	2	0	0	0	0	-2	-1	0	1	-2	3	0	1	-1	0	-2	-13	14	4	-2	29	-6	-15	-7	2
LB	17	-1	79	12	11	8	1	-1	0	0	-3	-3	2	0	-1	0	0	6	-8	0	-5	-14	10	-3	-6	19	1	-11	2	3
WN	49	68	-16	14	8	4	1	0	0	0	-1	-2	2	0	-5	3	0	8	-2	0	-5	-13	9	1	-7	25	7	-2	-5	1
HNsk	19	-2	115	15	15	9	1	-1	0	0	-4	-4	1	0	-1	0	0	7	6	0	-6	-13	12	0	-7	18	1	-9	5	-76
HN	19	-2	115	15	15	9	1	-1	0	0	-4	-4	1	0	-1	0	0	7	6	0	-6	-13	12	0	-7	18	1	-9	5	-76
KUEN	25	11	39	5	1	6	2	1	0	0	-5	-4	0	0	-1	1	0	5	1	0	-5	-13	12	-6	-7	30	1	-16	2	-2
SHA	34	28	10	3	-3	6	1	0	0	0	-5	-2	0	1	-1	1	0	5	1	0	-3	-13	13	-5	-4	32	0	-16	-4	0
TBB	13	-8	97	12	12	17	0	1	0	0	-11	-6	1	0	0	-1	0	8	1	0	-5	-13	12	-14	-7	22	-3	-26	5	-1
HDH	31	24	11	13	7	10	0	0	0	0	-5	-1	3	0	-1	-3	0	7	-1	0	-4	-13	19	0	-4	40	0	-15	2	-68
AA	42	51	-9	13	7	8	0	-1	0	0	-4	-2	2	0	-1	-1	0	8	-1	0	-3	-13	11	-3	-2	29	-2	-14	-4	-1
BAD	16	10	8	26	30	4	9	1	0	0	-3	-8	3	0	-1	-2	0	11	3	0	-6	-20	20	13	-11	31	21	14	13	-11
KAsk	12	-5	72	25	31	9	4	0	0	0	-4	-7	2	0	0	-2	0	8	10	0	-6	-13	15	2	-7	21	9	-3	12	-2
KA	12	-5	72	25	31	9	4	0	0	0	-4	-7	2	0	0	-2	0	8	10	0	-6	-13	15	2	-7	21	9	-3	12	-2
RA	16	10	8	26	30	4	9	1	0	0	-3	-8	3	0	-1	-2	0	11	3	0	-6	-20	20	13	-11	31	21	14	13	-11
HDsk	14	-3	70	16	17	10	2	-1	0	0	-4	-6	1	0	-1	0	0	9	7	0	-6	-13	11	-2	-7	20	6	-7	5	1
MAsk	14	-3	70	16	17	10	2	-1	0	0	-4	-6	1	0	-1	0	0	9	7	0	-6	-13	11	-2	-7	20	6	-7	5	1
MOS	21	5	47	13	10	14	1	1	0	0	-8	-7	0	0	-1	1	0	8	-3	0	-5	-13	12	-10	-6	26	-2	-22	3	-1
HD	14	-3	70	16	17	10	2	-1	0	0	-4	-6	1	0	-1	0	0	9	7	0	-6	-13	11	-2	-7	20	6	-7	5	1
PFsk	27	19	14	18	14	6	1	4	0	0	-5	-4	3	0	-9	6	0	5	-22	0	-5	-23	6	-7	-8	14	-2	-14	-1	5
CW	46	59	-11	22	13	8	0	0	0	0	-3	-4	2	0	-2	0	0	10	-3	0	-3	-23	13	0	-10	33	4	-8	-5	-48

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	**%**	**%**	**%**	**%**	**pp[o]**	**pp[o]**	**pp[o]**	**pp[o]**	**pp[o]**	**pp[o]**	**pp[o]**	**pp[o]**	**pp[o]**	**pp[o]**	**pp[o]**	**pp[o]**	**pp[o]**	**pp[o]**	**%[t]**	**%[t]**	**%[t]**	**%**	**%**	**%**	**%**	**%[v]**	**%[v]**	**%**	**pp[o]**
PF	27	19	14	18	14	6	1	4	0	0	-5	-4	3	0	-9	6	0	5	-22	0	-5	-23	6	-7	-8	14	-2	-14	-1	5
FDS	45	55	-7	18	8	10	0	0	0	0	-6	-4	1	0	-2	1	0	9	-2	0	-2	-13	12	-4	-9	29	-1	-15	-1	-49
FRsk	44	68	-28	14	9	4	5	0	0	0	-2	-3	5	0	-3	-2	0	8	-2	0	-6	-13	13	9	-7	28	22	18	2	-6
FR	44	68	-28	14	9	4	5	0	0	0	-2	-3	5	0	-3	-2	0	8	-2	0	-6	-13	13	9	-7	28	22	18	2	-6
EM	25	35	-27	12	9	1	7	0	0	0	0	-4	4	0	-1	-3	0	9	1	0	-6	-13	12	9	-8	25	22	19	3	-10
OG	24	29	-19	15	14	4	7	0	0	0	-2	-5	4	0	-3	-2	0	9	0	0	-6	-13	11	7	-10	24	22	17	3	-7
RW	41	44	-3	10	-2	5	0	0	0	0	-8	-1	0	3	-2	5	0	3	0	0	-3	-13	14	-2	-7	30	-13	-26	0	4
VS	72	101	0	19	3	-3	0	2	0	0	-6	-3	0	10	-1	11	0	-6	-1	0	-4	-13	6	-1	-3	9	-30	-35	-7	9
TUT	73	105	-1	21	2	-2	0	2	0	0	-5	-4	0	9	-1	9	0	-4	-1	0	-3	-20	-1	-8	-5	5	-29	-34	-6	-31
KN	33	31	1	15	10	10	1	0	0	0	-5	-4	1	0	-2	1	0	5	-2	0	-5	-13	9	-4	-7	24	-1	-13	1	0
LOE	55	99	-32	17	8	0	3	1	0	0	-1	-2	1	0	1	-1	0	3	2	0	-7	-13	6	3	-6	20	9	6	-1	-5
WT	55	89	-23	17	6	5	0	-1	0	0	-2	-2	0	0	-2	1	0	5	-1	0	-4	-13	6	-2	-6	23	2	-6	-6	3
RT	52	71	-13	21	11	7	0	3	0	0	-4	-3	3	0	0	-2	0	8	0	0	-6	-13	11	-1	-8	34	0	-11	-4	-52
TUE	34	23	25	15	5	3	1	0	0	0	-4	-5	0	5	-3	9	0	-1	18	0	-1	-14	14	-4	-3	22	-5	-20	7	63
BL	62	96	-15	18	-5	-8	0	0	0	0	-5	-3	0	15	0	15	0	-7	0	0	-1	-23	-8	-14	-2	-12	-41	-45	-6	53
ULsk	26	12	34	9	4	12	1	0	0	0	-7	-2	2	0	-1	-1	0	8	0	0	-3	-13	14	-9	-6	30	-2	-22	0	-2
UL	26	12	34	9	4	12	1	0	0	0	-7	-2	2	0	-1	-1	0	8	0	0	-3	-13	14	-9	-6	30	-2	-22	0	-2
BC	28	22	10	5	1	8	1	1	0	0	-5	-2	2	0	-5	3	0	6	-1	0	-5	-13	8	-8	-6	26	-1	-16	-2	1
FN	39	51	-17	13	10	6	2	1	0	0	-5	-2	3	0	-1	-2	0	4	0	0	-6	-13	7	0	-7	20	9	2	-3	-2
RV	83	190	-34	14	7	2	1	0	0	0	-1	-1	1	0	2	-3	0	2	3	0	-5	-14	0	-4	-4	7	5	1	-5	-3
SIG	35	31	7	7	1	7	0	2	0	0	-5	-3	1	0	-1	0	0	5	-1	0	-5	-13	11	-7	-7	28	-8	-23	2	-3

m: Subsidy. n: Total gross margin. o: Percent share of utilized agricultural area/percentage points of utilized agricultural area compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare. t: u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. vu: Percentage points difference from reference year. wv: Green house gas. xw: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. n.c.: not calculated.

Table 5.1-5: Development of potential AEM area in NUTS3 regions in the scenario CAP2003 (results from Section 3.1).

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	pp	pp	pp	pp	pp	pp	pp
S	55	0	12	6	0	31	0	-64	-62	0	0	0	-6	0
BB	83	0	0	14	14	54	0	-5	-70	0	0	0	-6	0
ES	110	0	16	32	32	30	0	-50	0	0	1	1	-1	0
GP	124	0	12	43	43	27	0	-6	0	0	-2	-2	-2	0
LB	138	0	11	3	3	42	0	-10	-78	0	-1	-1	-10	0
WN	102	0	13	32	32	25	0	-9	0	3	-5	-5	-3	0
HNsk	137	0	8	3	3	46	0	73	-78	0	0	0	-6	0
HN	137	0	8	3	3	46	0	73	-78	0	0	0	-6	0
KUEN	83	0	7	14	14	47	0	-8	0	0	-2	-2	-4	0
SHA	111	0	6	28	28	48	0	-6	0	0	-2	-2	-1	0
TBB	88	0	4	7	7	70	0	-5	0	0	0	0	-5	0
HDH	106	0	6	25	25	50	0	-5	-65	0	0	0	-5	0
AA	118	0	8	37	37	37	0	-7	0	0	-2	-2	-4	0
BAD	68	0	7	17	17	27	0	0	0	0	0	0	0	0
KAsk	151	0	6	8	8	45	0	-8	-82	0	0	0	-8	0
KA	151	0	6	8	8	45	0	-8	-82	0	0	0	-8	0
RA	68	0	7	17	17	27	0	0	0	0	0	0	0	0
HDsk	145	0	12	3	3	44	0	-8	-80	0	0	0	-7	0
MAsk	145	0	12	3	3	44	0	-8	-80	0	0	0	-7	0
MOS	101	0	7	17	17	61	0	0	0	0	0	0	0	0
HD	145	0	12	3	3	44	0	-8	-80	0	0	0	-7	0
PFsk	71	0	0	22	22	28	0	-96	-64	-10	0	0	-18	0
CW	132	0	10	43	43	36	0	1	-48	0	3	3	-5	1
PF	71	0	0	22	22	28	0	-96	-64	-10	0	0	-18	0
FDS	132	0	9	41	41	39	1	0	-50	0	2	2	-4	1
FRsk	73	0	27	16	16	13	0	-2	0	0	0	0	-2	0
FR	73	0	27	16	16	13	0	-2	0	0	0	0	-2	0
EM	64	0	26	14	14	9	0	-4	0	1	-1	-1	-2	0

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
OG	77	0	14	23	23	18	0	1	0	0	0	0	1	0
RW	129	0	8	38	38	44	1	-2	0	0	-2	-2	3	-1
VS	147	0	14	56	56	21	0	-1	0	0	0	0	0	0
TUT	157	0	5	65	65	22	0	0	-38	0	0	0	0	0
KN	95	0	12	24	24	36	0	-10	0	1	-3	-3	-5	0
LOE	88	0	35	22	22	10	0	-6	0	-7	0	0	-2	0
WT	167	0	15	42	42	25	0	-3	-40	0	-2	-2	-1	0
RT	127	0	7	42	42	36	0	-2	-47	0	-1	-1	0	0
TUE	170	0	10	24	24	46	0	-4	0	9	-7	-7	-4	0
BL	157	0	13	63	63	16	1	-25	0	0	1	1	-2	0
ULsk	100	0	5	18	18	58	0	-5	0	0	-1	-1	-4	0
UL	100	0	5	18	18	58	0	-5	0	0	-1	-1	-4	0
BC	97	0	4	27	27	39	0	-10	0	0	-2	-2	-8	0
FN	76	0	13	23	23	18	0	-7	0	0	-1	-1	-4	0
RV	108	0	40	27	27	14	0	-5	0	-5	0	0	0	0
SIG	175	0	6	29	29	46	0	61	0	0	-1	-1	-3	0

%UAA: Percentage share of utilized agricultural area. pp: percentage points. NA-2: Crop rotation with four crop groups. NB-1: Cattle density is between 0.3 and 2.0 LU per hectares. NB-2: Cattle density is between 0.3 and 1.4 LU per hectares. NC-4: Regional typical pasture. NE-2: Greening of arable area in autumn. NE-3: Greening of set-aside area.

Table 5.1-6: Development of crop production area in NUTS3 regions in the scenario CAP2003 (Section 3.1).

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
S	22	0	0	1	13	0	0	6	0	1	2	0	3	7	1	0	2	4	14	0	37	0	2	0	12	6	0	0
BB	38	1	1	2	14	1	0	1	0	1	1	0	3	1	2	0	3	1	0	0	59	0	3	0	12	14	0	0
ES	19	2	1	2	6	2	0	4	0	0	1	0	0	4	1	0	3	1	1	0	32	0	0	0	16	30	0	0
GP	18	2	1	6	0	2	0	0	0	0	0	0	0	0	2	0	5	0	0	0	29	0	0	1	12	45	0	0
LB	33	2	0	3	13	1	0	6	0	0	1	0	9	2	1	0	5	1	5	0	51	0	2	0	11	4	0	0
WN	19	2	1	5	3	0	0	4	0	0	1	0	1	2	1	0	5	2	4	0	28	0	2	0	10	37	0	0
HNsk	32	1	1	2	16	0	0	5	0	0	3	0	11	3	1	0	3	2	9	0	51	0	1	0	7	3	0	0
HN	32	1	1	2	16	0	0	5	0	0	3	0	11	3	1	0	3	2	9	0	51	0	1	0	7	3	0	0
KUEN	36	2	0	9	0	2	0	5	0	0	0	0	5	1	3	0	5	2	2	0	51	0	0	0	7	16	0	0
SHA	25	1	1	17	0	2	0	2	0	0	0	0	1	0	3	0	6	0	0	0	49	0	0	1	6	31	0	0
TBB	36	1	1	3	31	1	0	1	0	0	0	0	3	0	4	0	4	0	1	0	75	0	1	0	4	7	0	0
HDH	40	1	1	8	0	0	0	1	0	1	1	0	1	0	4	0	6	0	0	0	54	0	3	0	6	25	0	0
AA	24	1	1	7	7	0	0	1	0	0	0	0	0	0	2	0	8	0	0	0	40	0	2	0	8	38	0	0
BAD	17	1	6	2	2	0	0	34	0	0	1	0	0	3	1	0	1	3	2	0	27	0	3	0	7	17	0	0
KAsk	27	2	8	2	14	0	0	16	0	1	1	0	5	2	2	1	1	1	2	0	53	0	2	0	6	8	0	0
KA	27	2	8	2	14	0	0	16	0	1	1	0	5	2	2	1	1	1	2	0	53	0	2	0	6	8	0	0
RA	17	1	6	2	2	0	0	34	0	0	1	0	0	3	1	0	1	3	2	0	27	0	3	0	7	17	0	0
HDsk	30	2	2	3	15	0	0	11	0	0	1	0	7	2	1	1	4	1	1	0	52	0	1	0	12	3	0	0
MAsk	30	2	2	3	15	0	0	11	0	0	1	0	7	2	1	1	4	1	1	0	52	0	1	0	12	3	0	0
MOS	39	1	1	4	14	0	0	2	0	0	0	0	2	0	3	0	5	0	0	0	61	0	0	0	7	17	0	0
HD	30	2	2	3	15	0	0	11	0	0	1	0	7	2	1	1	4	1	1	0	52	0	1	0	12	3	0	0
PFsk	26	1	2	3	12	0	0	4	0	0	1	0	1	0	3	1	4	0	1	0	46	0	3	0	10	22	0	0
CW	20	1	1	3	13	0	0	0	0	0	1	0	0	0	2	0	3	0	0	0	41	0	2	0	10	40	0	0
PF	26	1	2	3	12	0	0	4	0	0	1	0	1	0	3	1	4	0	1	0	46	0	3	0	10	22	0	0

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
FDS	24	1	1	4	12	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	43	0	1	0	9	39	0	0
FRsk	8	1	1	1	4	0	0	22	0	0	1	0	0	2	0	0	1	2	10	0	15	0	5	0	27	16	0	0
FR	8	1	1	1	4	0	0	22	0	0	1	0	0	2	0	0	1	2	10	0	15	0	5	0	27	16	0	0
EM	10	1	0	1	0	0	0	30	0	0	1	0	0	1	0	0	2	3	8	0	11	0	4	0	25	16	0	0
OG	16	1	0	1	0	0	0	29	0	0	1	0	0	1	0	0	2	7	4	0	17	0	4	0	14	23	0	0
RW	32	1	1	7	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	1	42	0	0	3	8	40	0	0
VS	11	0	1	2	7	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	21	0	0	10	14	56	0	0
TUT	12	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	22	0	0	9	5	65	0	0
KN	25	0	1	5	10	0	0	5	0	0	0	0	0	1	0	1	5	3	0	0	41	0	1	0	11	27	0	0
LOE	9	1	0	1	1	0	0	13	0	0	0	0	0	1	0	0	3	3	3	0	11	0	1	0	42	21	0	0
WT	14	1	1	3	8	0	0	2	0	0	0	0	0	0	1	1	4	0	0	0	26	0	0	0	14	44	0	0
RT	18	0	1	2	15	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	37	0	3	0	7	43	0	0
TUE	23	1	1	6	9	5	0	3	0	0	1	0	1	0	6	1	1	0	0	0	50	0	0	5	7	31	0	0
BL	9	0	1	2	5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	19	0	0	15	13	63	0	0
ULsk	37	1	1	5	17	0	0	2	0	0	0	0	0	0	3	0	5	0	0	0	62	0	2	0	5	18	0	0
UL	37	1	1	5	17	0	0	2	0	0	0	0	0	0	3	0	5	0	0	0	62	0	2	0	5	18	0	0
BC	33	1	0	7	3	0	0	2	0	0	0	0	0	0	2	0	10	0	0	0	47	0	2	0	4	28	0	0
FN	14	2	0	3	4	1	0	7	0	0	0	0	0	2	1	1	5	18	1	0	22	0	3	0	13	24	0	0
RV	8	1	0	4	1	1	0	2	0	0	0	0	0	0	1	0	7	1	0	0	14	0	1	0	45	27	0	0
SIG	29	1	1	6	11	0	0	1	0	0	1	0	0	0	3	0	3	0	0	0	49	0	1	0	6	30	0	0

pp: percentage points.

Table 5.1-7: Development of economic, production and environmental indicator values in NUTS3 regions in the scenario SUBred60% (results from Section 3.2).

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	% [t]	% [t]	% [t]	%	%	%	%	%[v]	%[v]	%	pp[o]
S	-110	-113	-35	-20	-10	-7	-2	1	0	0	2	2	-4	0	1	3	0	0	0	4	24	-11	-16	-8	3	11	-15	-6	6	5
BB	-85	-84	-29	-36	-19	-10	0	0	0	0	5	3	-3	0	1	2	0	0	0	5	13	-8	-11	-15	3	9	-28	-1	17	-4
ES	-110	-148	9	-37	-18	-4	-1	-1	0	0	2	3	0	1	3	-2	0	0	0	4	14	-4	-1	-5	5	8	-17	-3	8	3
GP	-126	-196	14	-27	-5	-4	0	0	0	0	2	1	0	1	2	-5	0	4	0	1	13	-2	1	-13	-2	2	-31	6	16	7
LB	-70	-58	-79	-20	-11	-8	-1	1	0	0	3	3	-2	0	1	0	0	0	0	5	14	-6	8	-10	3	6	-20	-1	11	-2
WN	-115	-169	15	-23	-7	-3	-1	-1	0	0	1	2	-2	0	8	-6	0	0	0	6	13	-8	5	-6	1	8	-21	-8	2	6
HNsk	-73	-57	-115	-22	-15	-9	-1	1	0	0	4	4	-1	0	1	0	0	0	0	6	13	-7	-6	-13	-1	7	-19	-1	9	-5
HN	-73	-57	-115	-22	-15	-9	-1	1	0	0	4	4	-1	0	1	0	0	0	0	6	13	-7	-6	-13	-1	7	-19	-1	9	-5
KUEN	-81	-78	-39	-13	-1	-5	-2	-1	0	0	4	4	0	0	1	-1	0	0	0	5	13	-5	-1	-12	6	7	-30	-1	16	-2
SHA	-98	-109	-18	-12	5	-10	-1	0	0	0	4	2	0	-2	1	-3	0	7	0	3	13	-9	-1	-11	8	4	-35	-1	17	2
TBB	-63	-47	-97	-26	-12	-16	0	-1	0	0	10	6	-1	0	0	1	0	0	0	5	13	-8	-1	-12	14	7	-23	3	26	-5
HDH	-89	-99	-12	-26	-7	-9	0	0	0	0	4	1	-3	0	1	3	0	0	0	4	13	-7	1	-19	0	4	-40	0	14	-2
AA	-108	-145	4	-25	-8	-12	0	1	0	0	4	2	-4	0	1	1	0	5	0	3	13	-13	1	-7	8	2	-26	1	15	4
BAD	-72	-76	-9	-41	-31	-4	-8	-1	0	0	3	8	-3	0	1	2	0	0	0	7	20	-12	-5	-19	-12	11	-30	-20	-13	-12
KAsk	-64	-52	-71	-42	-31	-9	-4	0	0	0	3	7	-2	0	0	2	0	0	0	6	13	-10	-10	-16	-3	6	-22	-10	2	-12
KA	-64	-52	-71	-42	-31	-9	-4	0	0	0	3	7	-2	0	0	2	0	0	0	6	13	-10	-10	-16	-3	6	-22	-10	2	-12
RA	-72	-76	-9	-41	-31	-4	-8	-1	0	0	3	8	-3	0	1	2	0	0	0	7	20	-12	-5	-19	-12	11	-30	-20	-13	-12
HDsk	-66	-55	-70	-28	-17	-9	-2	1	0	0	3	6	-1	0	1	0	0	0	0	6	13	-9	-7	-10	2	7	-19	-6	7	-4
MAsk	-66	-55	-70	-28	-17	-9	-2	1	0	0	3	6	-1	0	1	0	0	0	0	6	13	-9	-7	-10	2	7	-19	-6	7	-4
MOS	-81	-72	-61	-32	-13	-25	-1	-1	0	0	9	7	0	1	1	0	0	9	0	5	13	-20	14	-14	13	6	-35	4	29	-8
HD	-66	-55	-70	-28	-17	-9	-2	1	0	0	3	6	-1	0	1	0	0	0	0	6	13	-9	-7	-10	2	7	-19	-6	7	-4
PFsk	-84	-91	-14	-39	-19	-9	-1	-5	0	0	5	4	-6	0	13	-7	0	0	0	6	23	-10	25	-2	12	9	-8	-6	8	2
CW	-116	-160	4	-43	-17	-17	0	0	0	0	3	4	-4	0	2	0	0	8	0	3	23	-19	3	-6	10	10	-30	-13	3	3

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	% [t]	% [t]	% [t]	%	%	%	%	%[v]	%[v]	%	pp[o]
PF	-84	-91	-14	-39	-19	-9	-1	-5	0	0	5	4	-6	0	13	-7	0	0	0	6	23	-10	25	-2	12	9	-8	-6	8	2
FDS	-117	-155	-4	-38	-8	-20	0	0	0	0	6	4	-2	0	2	-3	0	11	0	1	13	-19	2	-4	16	9	-24	-7	12	-2
FRsk	-111	-169	27	-24	-10	-6	-4	0	0	0	2	3	-6	0	4	2	0	0	0	6	13	-9	3	-12	-7	7	-27	-21	-16	-1
FR	-111	-169	27	-24	-10	-6	-4	0	0	0	2	3	-6	0	4	2	0	0	0	6	13	-9	3	-12	-7	7	-27	-21	-16	-1
EM	-84	-116	27	-21	-8	0	-7	0	0	0	0	4	-4	0	1	3	0	0	0	6	13	-9	0	-13	-10	8	-25	-22	-20	-3
OG	-82	-106	20	-23	-14	-4	-7	0	0	0	2	5	-4	0	3	2	0	0	0	6	13	-8	2	-12	-8	10	-25	-23	-17	-3
RW	-110	-136	-6	-23	10	-7	0	0	0	0	7	0	0	-6	2	-10	0	10	0	2	13	-6	-1	-14	3	6	-37	15	29	-4
VS	-144	-224	-3	-36	-4	0	0	-2	0	0	6	3	0	-11	1	-12	0	3	0	5	13	3	2	-1	6	3	-5	26	32	6
TUT	-151	-235	-7	-42	-2	-3	0	-2	0	0	5	4	0	-12	1	-13	0	9	0	2	20	-1	2	6	15	3	-1	23	29	3
KN	-94	-111	-3	-30	-13	-13	-1	0	0	0	4	4	-2	0	2	1	0	3	0	5	13	-9	2	-5	9	8	-21	-1	13	-1
LOE	-126	-218	32	-30	-8	0	-3	-2	0	0	1	2	-2	1	0	1	0	0	0	7	13	-4	-2	-6	-3	6	-22	-9	-6	1
WT	-123	-203	24	-34	-8	-8	0	1	0	0	2	2	0	2	2	2	0	0	0	4	13	-8	2	-5	4	6	-22	-7	3	7
RT	-118	-174	13	-37	-11	-7	0	-3	0	0	4	3	-3	0	0	2	0	0	0	6	13	-8	0	-11	1	8	-33	1	11	4
TUE	-103	-104	-43	-34	3	-9	-1	0	0	0	3	5	0	-9	6	-17	0	13	0	-2	14	-5	-30	-13	8	0	-24	5	23	-15
BL	-150	-229	-3	-42	15	4	0	0	0	0	4	2	0	-27	0	-30	0	20	0	-1	23	3	1	22	29	-1	21	41	47	4
ULsk	-82	-79	-34	-20	-4	-11	-1	0	0	0	6	2	-2	0	1	1	0	0	0	3	13	-9	-3	-15	8	6	-31	2	22	0
UL	-82	-79	-34	-20	-4	-11	-1	0	0	0	6	2	-2	0	1	1	0	0	0	3	13	-9	-3	-15	8	6	-31	2	22	0
BC	-85	-96	-11	-13	-1	-7	-1	-2	0	0	5	2	-2	0	9	-7	0	0	0	5	13	-6	4	-6	9	6	-23	-1	14	3
FN	-102	-142	17	-19	-10	-7	-2	-1	0	0	5	2	-4	0	1	3	0	0	0	6	13	-6	1	-7	1	7	-19	-10	-2	4
RV	-165	-364	34	-22	-7	-2	-1	0	0	0	1	1	-1	0	-1	3	0	0	0	5	14	-3	-2	-1	3	4	-8	-6	-2	5
SIG	-94	-110	-7	-18	-1	-6	0	-2	0	0	4	3	-1	0	1	0	0	0	0	5	13	-5	1	-11	7	7	-28	8	23	-2

m: Subsidy. n: Total gross margin. o: Percent share of utilized agricultural area/percentage points of utilized agricultural area compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare. t: u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. vu: Percentage points difference from reference year. wv: Green house gas. xw: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. n.c.: not calculated.

Table 5.1-8: Development of potential AEM area in NUTS3 regions in the scenario SUBred60% (results from Section 3.2).

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	pp	pp	pp	pp	pp	pp	pp
S	-5	0	-12	2	0	3	0	12	22	-12	2	0	3	0
BB	28	23	0	0	0	5	0	1	66	0	0	0	6	0
ES	10	10	0	0	0	0	0	28	-22	0	0	0	0	0
GP	8	7	0	0	0	0	0	0	0	0	1	1	0	0
LB	-21	48	0	1	1	10	0	9	77	0	1	1	10	0
WN	27	20	0	2	2	3	0	7	0	0	2	2	4	0
HNsk	-40	32	-1	0	0	5	0	-72	79	0	0	0	6	0
HN	-40	32	-1	0	0	5	0	-72	79	0	0	0	6	0
KUEN	15	8	0	2	2	4	0	8	0	0	2	2	4	0
SHA	7	9	0	1	1	-3	0	2	5	0	1	1	-4	0
TBB	35	29	0	0	0	5	0	1	-3	0	0	0	5	0
HDH	9	5	0	0	0	4	0	5	65	0	0	0	5	0
AA	5	3	0	1	1	-1	0	-14	-16	0	1	1	-1	0
BAD	4	5	1	0	0	0	0	-9	-9	1	0	0	0	0
KAsk	-13	62	0	1	1	8	0	8	82	0	1	1	8	0
KA	-13	62	0	1	1	8	0	8	82	0	1	1	8	0
RA	4	5	1	0	0	0	0	-9	-9	1	0	0	0	0
HDsk	-19	55	0	1	1	8	0	8	80	0	0	0	7	0
MAsk	-19	55	0	1	1	8	0	8	80	0	0	0	7	0
MOS	34	42	0	1	1	-10	0	-1	7	0	1	1	-10	0
HD	-19	55	0	1	1	8	0	8	80	0	0	0	7	0
PFsk	34	6	14	-1	-1	15	0	53	22	14	-1	-1	15	0
CW	-7	2	0	-3	-3	-4	0	-28	29	0	-3	-3	-4	-1
PF	34	6	14	-1	-1	15	0	53	22	14	-1	-1	15	0
FDS	-11	3	0	-3	-3	-5	-1	-24	39	0	-3	-3	-5	-1
FRsk	4	3	1	0	0	0	0	-16	-17	1	0	0	0	0
FR	4	3	1	0	0	0	0	-16	-17	1	0	0	0	0
EM	12	9	-1	2	2	3	0	8	4	-1	1	1	2	0

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
OG	11	10	0	0	0	0	0	5	6	0	0	0	0	0
RW	-1	11	0	-4	-4	-5	-2	-4	8	0	-4	-4	-5	0
VS	0	3	0	0	0	-3	0	-8	-5	0	0	0	-2	0
TUT	-11	1	1	-4	-4	-5	0	-19	31	1	-3	-3	-5	0
KN	12	2	-1	4	4	1	0	-20	-30	-1	4	4	2	0
LOE	10	2	7	-1	-1	1	0	4	-4	8	0	0	1	0
WT	-25	10	-1	5	5	-1	0	-13	22	0	5	5	-1	0
RT	17	15	0	1	1	1	0	4	48	0	1	1	1	0
TUE	-37	34	0	-1	-1	-3	0	-16	-7	0	-1	-1	-3	0
BL	-26	7	0	-15	-15	-2	-2	-17	-8	0	-15	-15	-3	-1
ULsk	31	27	0	0	0	4	0	6	1	0	1	1	4	0
UL	31	27	0	0	0	4	0	6	1	0	1	1	4	0
BC	23	15	4	-2	-2	8	0	7	1	4	-2	-2	8	0
FN	15	7	0	2	2	3	0	-6	-14	0	3	3	3	0
RV	7	3	6	-1	-1	0	0	2	-3	6	0	0	0	0
SIG	-31	29	0	1	1	3	0	-64	-3	0	1	1	3	0

%UAA: Percentage share of utilized agricultural area. pp: percentage points. NA-2: Crop rotation with four crop groups. NB-1: Cattle density is between 0.3 and 2.0 LU per hectares. NB-2: Cattle density is between 0.3 and 1.4 LU per hectares. NC-4: Regional typical pasture. NE-2: Greening of arable area in autumn. NE-3: Greening of set-aside area.

Table 5.1-9: Development of crop production area in NUTS3 regions in the scenario SUBred60% (results from Section 3.2).

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
S	2	0	0	0	-15	5	0	-2	0	0	0	0	0	0	1	0	-1	1	2	-25	0	0	0	-4	0	1	3	0
BB	-16	0	0	3	0	4	0	0	0	-1	0	0	0	0	4	1	-1	1	3	-38	0	0	0	-3	0	1	2	0
ES	-3	-1	0	3	-6	3	0	-1	0	0	0	0	0	0	2	0	-2	1	3	-24	0	0	0	0	1	3	-2	0
GP	-10	-1	-1	-1	5	3	0	0	0	0	0	0	0	0	1	0	-1	1	1	-24	0	0	0	0	1	2	-5	0
LB	-11	0	0	3	-1	1	0	-1	0	0	0	0	0	0	1	2	-1	2	3	-27	0	0	0	-2	0	1	0	0
WN	-9	-1	0	1	1	5	0	-1	0	0	0	0	0	0	1	0	-1	1	2	-19	0	0	0	-2	0	8	-6	0
HNsk	-10	0	0	2	-3	1	0	-1	0	1	0	0	0	0	2	2	0	1	4	-24	0	0	0	-1	0	1	0	0
HN	-10	0	0	2	-3	1	0	-1	0	1	0	0	0	0	2	2	0	1	4	-24	0	0	0	-1	0	1	0	0
KUEN	-17	-1	0	4	4	4	0	-2	0	0	0	0	0	0	4	0	-2	1	4	-39	0	0	0	0	0	1	-1	0
SHA	-11	-1	-1	-5	4	5	0	-1	0	1	0	0	0	0	3	0	0	1	2	-43	0	0	0	0	-2	1	-4	0
TBB	-15	0	0	6	-10	3	0	0	0	1	0	0	0	0	8	1	-2	1	6	-53	0	0	0	-1	0	0	1	0
HDH	-22	0	-1	0	9	4	0	0	0	1	0	0	0	0	3	0	0	1	1	-36	0	0	0	-3	0	1	3	0
AA	-10	0	0	3	-10	5	0	0	0	0	0	0	0	0	3	0	0	1	2	-35	0	0	0	-4	0	1	1	0
BAD	-7	0	-1	1	0	3	0	-8	0	1	0	0	0	0	1	1	-1	1	8	-15	0	0	0	-3	0	1	2	0
KAsk	-8	0	-2	1	-2	3	0	-4	0	0	0	0	0	0	2	2	-1	1	7	-25	0	0	0	-2	0	0	2	0
KA	-8	0	-2	1	-2	3	0	-4	0	0	0	0	0	0	2	2	-1	1	7	-25	0	0	0	-2	0	0	2	0
RA	-7	0	-1	1	0	3	0	-8	0	1	0	0	0	0	1	1	-1	1	8	-15	0	0	0	-3	0	1	2	0
HDsk	-10	0	0	2	-3	2	0	-2	0	0	0	0	0	0	2	2	0	1	6	-27	0	0	0	-1	0	1	0	0
MAsk	-10	0	0	2	-3	2	0	-2	0	0	0	0	0	0	2	2	0	1	6	-27	0	0	0	-1	0	1	0	0
MOS	-38	0	0	11	-2	4	0	-1	0	0	0	0	0	0	9	0	-2	1	7	-56	0	0	0	0	1	1	0	0
HD	-10	0	0	2	-3	2	0	-2	0	0	0	0	0	0	2	2	0	1	6	-27	0	0	0	-1	0	1	0	0
PFsk	-2	0	1	3	-15	4	0	-1	0	0	0	0	0	0	4	1	-5	1	4	-31	0	0	0	-6	0	13	-7	0
CW	-6	0	-1	0	-17	6	0	0	0	0	0	0	0	0	2	0	0	1	4	-38	0	0	0	-4	0	2	0	0
PF	-2	0	1	3	-15	4	0	-1	0	0	0	0	0	0	4	1	-5	1	4	-31	0	0	0	-6	0	13	-7	0

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
FDS	-10	-1	-1	2	-17	6	0	0	0	0	0	0	0	0	5	0	0	0	4	-44	0	0	0	-2	0	2	-3	0
FRsk	-1	0	0	0	-5	1	0	-4	0	0	0	0	0	0	0	1	0	0	3	-11	0	0	0	-6	0	4	2	0
FR	-1	0	0	0	-5	1	0	-4	0	0	0	0	0	0	0	1	0	0	3	-11	0	0	0	-6	0	4	2	0
EM	-5	0	0	0	2	2	0	-7	0	0	0	0	0	0	0	0	0	0	4	-5	0	0	0	-4	0	1	3	0
OG	-8	0	0	1	4	1	0	-7	0	0	0	0	0	0	0	1	0	1	5	-8	0	0	0	-4	0	3	2	0
RW	-26	0	0	-4	18	6	0	0	0	0	0	0	0	0	6	0	-1	0	0	-38	0	0	0	0	-6	2	-10	0
VS	0	0	0	4	-7	4	0	0	0	1	0	0	0	0	6	0	-2	0	3	-20	0	0	0	0	-11	1	-12	0
TUT	-1	0	0	5	-11	4	0	0	0	0	0	0	0	0	5	0	-2	1	4	-24	0	0	0	0	-12	1	-13	0
KN	-7	0	0	6	-13	2	0	-1	0	0	0	0	0	0	4	1	-2	2	4	-33	0	0	0	-2	0	2	1	0
LOE	-3	0	0	2	-1	1	0	-3	0	0	0	0	0	0	0	0	-3	1	2	-7	0	0	0	-2	1	0	1	0
WT	-4	0	0	3	-9	3	0	0	0	0	0	0	0	0	1	1	0	1	2	-22	0	0	0	0	2	2	2	0
RT	-9	0	0	2	-5	5	0	0	0	1	0	0	0	0	3	0	-3	0	3	-27	0	0	0	-3	0	0	2	0
TUE	-6	0	0	-2	0	0	0	-1	0	2	0	0	0	0	1	0	-1	1	5	-45	0	0	0	0	-9	6	-17	0
BL	0	0	0	2	-4	6	0	0	0	0	0	0	0	0	4	0	-1	1	2	-19	0	0	0	0	-27	0	-30	0
ULsk	-16	0	0	7	-6	4	0	-1	0	1	0	0	0	0	6	0	-1	1	2	-48	0	0	0	-2	0	1	1	0
UL	-16	0	0	7	-6	4	0	-1	0	1	0	0	0	0	6	0	-1	1	2	-48	0	0	0	-2	0	1	1	0
BC	-15	0	0	3	2	4	0	-1	0	0	0	0	0	0	4	0	-2	0	2	-36	0	0	0	-2	0	9	-7	0
FN	-5	0	0	2	-5	1	0	-2	0	0	0	0	0	0	1	3	-2	1	2	-16	0	0	0	-4	0	1	3	0
RV	-2	0	0	-1	-1	1	0	-1	0	0	0	0	0	0	1	0	0	0	1	-9	0	0	0	-1	0	-1	3	0
SIG	-13	0	0	5	-4	5	0	0	0	1	0	0	0	0	4	0	-4	2	3	-39	0	0	0	-1	0	1	0	0

pp: percentage points.

Table 5.1-10: Development of economic, production and environmental indicator values in NUTS3 regions in the scenario SUBshift70% (results from Section 3.2).

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	% [t]	% [t]	% [t]	%	%	%	%	%[v]	%[v]	%	pp[o]
S	-111	-126	6	-18	-7	-3	-2	-1	0	0	2	2	-2	0	1	1	0	0	0	3	23	-5	-28	-12	-2	10	-20	-3	7	3
BB	-84	-96	8	-40	-26	-11	0	0	0	0	6	3	-3	0	1	2	0	0	0	5	13	-10	-20	-10	8	9	-19	-1	17	-1
ES	-109	-164	37	-35	-16	-3	-1	-1	0	0	1	3	0	1	3	-2	0	0	0	4	14	-3	3	-7	3	7	-19	-3	8	3
GP	-125	-213	38	-27	-5	-4	0	0	0	0	1	1	0	1	2	-4	0	3	0	1	13	-3	0	-12	-2	2	-29	5	15	7
LB	-70	-68	-26	-19	-9	-7	-1	1	0	0	3	3	-2	0	1	0	0	0	0	4	14	-6	22	-10	3	6	-20	-1	10	-3
WN	-115	-186	40	-23	-7	-3	-1	-1	0	0	1	2	-2	0	8	-6	0	0	0	6	13	-7	1	-8	-1	8	-23	-8	1	6
HNsk	-73	-67	-53	-22	-15	-9	-1	1	0	0	4	4	-1	0	1	0	0	0	0	6	13	-7	-6	-13	-1	7	-19	-1	8	-5
HN	-73	-67	-53	-22	-15	-9	-1	1	0	0	4	4	-1	0	1	0	0	0	0	6	13	-7	-6	-13	-1	7	-19	-1	8	-5
KUEN	-81	-89	2	-13	0	-4	-2	-1	0	0	4	4	0	0	1	-1	0	0	0	5	13	-4	-3	-14	4	7	-33	-2	15	-3
SHA	-98	-121	12	-12	5	-10	-1	0	0	0	4	2	0	-2	1	-3	0	7	0	3	13	-9	-1	-14	6	3	-38	-1	17	2
TBB	-62	-56	-40	-30	-18	-21	0	0	0	0	13	6	-2	0	0	3	0	0	0	5	13	-12	3	-19	10	8	-31	6	29	-8
HDH	-88	-111	22	-26	-7	-10	0	0	0	0	4	1	-3	0	1	3	0	0	0	4	13	-7	1	-19	0	4	-41	-1	14	-2
AA	-106	-158	32	-25	-8	-11	0	1	0	0	4	2	-4	0	1	1	0	3	0	3	13	-12	3	-8	7	2	-28	1	14	4
BAD	-74	-87	24	-41	-31	-4	-9	-1	0	0	2	8	-3	0	1	2	0	0	0	6	20	-12	-6	-20	-13	11	-31	-21	-14	-12
KAsk	-64	-62	-19	-42	-31	-9	-4	0	0	0	3	7	-3	0	0	3	0	0	0	6	13	-9	-11	-16	-3	7	-22	-10	2	-12
KA	-64	-62	-19	-42	-31	-9	-4	0	0	0	3	7	-3	0	0	3	0	0	0	6	13	-9	-11	-16	-3	7	-22	-10	2	-12
RA	-74	-87	24	-41	-31	-4	-9	-1	0	0	2	8	-3	0	1	2	0	0	0	6	20	-12	-6	-20	-13	11	-31	-21	-14	-12
HDsk	-67	-65	-21	-33	-24	-13	-2	1	0	0	4	6	-2	1	1	2	0	0	0	7	13	-14	-13	-8	6	7	-16	-7	8	-3
MAsk	-67	-65	-21	-33	-24	-13	-2	1	0	0	4	6	-2	1	1	2	0	0	0	7	13	-14	-13	-8	6	7	-16	-7	8	-3
MOS	-86	-84	-38	-36	-17	-34	-1	-1	0	0	10	7	0	1	1	1	0	17	0	5	13	-29	18	-7	23	6	-29	4	32	-10
HD	-67	-65	-21	-33	-24	-13	-2	1	0	0	4	6	-2	1	1	2	0	0	0	7	13	-14	-13	-8	6	7	-16	-7	8	-3
PFsk	-83	-102	22	-38	-19	-8	-1	-4	0	0	5	4	-6	0	9	-3	0	0	0	5	23	-13	25	-6	9	8	-13	-5	9	1
CW	-111	-173	33	-41	-15	-13	0	0	0	0	3	4	-4	0	2	1	0	4	0	3	23	-15	8	-10	5	10	-32	-10	4	4

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	%[t]	%[t]	%[t]	%	%	%	%	%[v]	%[v]	%	pp[o]
PF	-83	-102	22	-38	-19	-8	-1	-4	0	0	5	4	-6	0	9	-3	0	0	0	5	23	-13	25	-6	9	8	-13	-5	9	1
FDS	-115	-169	21	-37	-9	-20	0	0	0	0	6	4	-2	0	2	-2	0	11	0	1	13	-19	2	-5	15	9	-25	-8	11	-2
FRsk	-113	-186	48	-25	-10	-6	-5	0	0	0	2	3	-6	0	4	2	0	0	0	7	13	-10	3	-12	-7	7	-27	-22	-18	-2
FR	-113	-186	48	-25	-10	-6	-5	0	0	0	2	3	-6	0	4	2	0	0	0	7	13	-10	3	-12	-7	7	-27	-22	-18	-2
EM	-86	-129	50	-21	-8	0	-8	0	0	0	0	4	-4	0	0	4	0	0	0	6	13	-9	-1	-13	-10	8	-26	-24	-21	-4
OG	-84	-119	45	-23	-14	-3	-8	0	0	0	2	5	-4	0	2	3	0	0	0	6	13	-8	-1	-13	-9	10	-26	-24	-19	-4
RW	-112	-151	15	-25	8	-12	0	0	0	0	7	0	0	-6	2	-10	0	14	0	2	13	-10	-1	-8	10	6	-31	10	27	-4
VS	-138	-243	26	-36	-4	0	0	-2	0	0	6	3	0	-7	1	-9	0	2	0	5	13	3	1	-2	6	3	-6	24	30	6
TUT	-143	-251	23	-38	0	1	0	-2	0	0	4	4	0	-9	1	-11	0	4	0	2	20	2	1	1	8	4	-8	27	33	5
KN	-93	-123	29	-30	-13	-13	-1	0	0	0	5	4	-2	1	1	2	0	2	0	5	13	-8	2	-6	8	7	-22	-2	12	-1
LOE	-126	-238	53	-30	-8	0	-3	-1	0	0	1	2	-1	0	-2	2	0	0	0	7	13	-4	-3	-6	-3	6	-21	-11	-8	1
WT	-121	-222	48	-34	-8	-8	0	1	0	0	2	2	0	3	2	3	0	0	0	4	13	-8	2	-7	2	6	-25	-9	1	6
RT	-116	-191	39	-37	-11	-7	0	-3	0	0	4	3	-3	0	0	3	0	0	0	6	13	-8	0	-11	0	8	-34	0	11	4
TUE	-102	-114	-9	-33	2	-10	-1	0	0	0	2	5	0	-8	4	-13	0	13	0	-2	14	-8	-23	-14	8	0	-26	2	21	-15
BL	-148	-245	17	-42	14	3	0	0	0	0	4	2	0	-23	0	-29	0	21	0	-1	23	2	-1	22	29	-1	20	39	44	3
ULsk	-81	-91	6	-20	-4	-11	-1	0	0	0	6	2	-2	0	1	1	0	0	0	3	13	-9	-3	-15	8	6	-31	1	21	0
UL	-81	-91	6	-20	-4	-11	-1	0	0	0	6	2	-2	0	1	1	0	0	0	3	13	-9	-3	-15	8	6	-31	1	21	0
BC	-84	-108	23	-13	-1	-6	-1	-2	0	0	4	2	-1	0	5	-3	0	0	0	5	13	-5	-3	-10	6	5	-30	0	15	1
FN	-102	-157	43	-19	-10	-7	-2	-1	0	0	5	2	-5	0	1	4	0	0	0	6	13	-6	0	-7	1	7	-20	-12	-4	3
RV	-164	-393	54	-22	-8	-2	-1	0	0	0	1	1	-2	0	-2	3	0	0	0	5	14	-3	-3	-1	3	3	-8	-7	-3	5
SIG	-95	-124	22	-19	-3	-10	0	-3	0	0	4	3	-2	0	1	1	0	3	0	5	13	-8	4	-8	11	8	-24	6	22	-2

m: Subsidy. n: Total gross margin. o: Percent share of utilized agricultural area/percentage points of utilized agricultural area compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare. t: u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. vu: Percentage points difference from reference year. wv: Green house gas. xw: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. n.c.: not calculated.

Table 5.1-11: Development of potential AEM area in NUTS3 regions in the scenario SUBshift70% (results from Section 3.2).

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	pp	pp	pp	pp	pp	pp	pp
S	35	40	-12	0	0	6	0	52	62	-12	1	0	6	0
BB	8	3	0	0	0	5	0	-20	46	0	1	1	5	0
ES	32	32	0	-1	-1	1	0	50	-1	0	0	0	1	0
GP	9	6	0	1	1	0	0	1	-1	0	1	1	0	0
LB	-22	46	0	1	1	10	0	8	75	-1	1	1	11	0
WN	37	31	0	1	1	4	0	17	10	0	1	1	5	0
HNsk	-40	32	-1	0	0	6	0	-72	78	0	0	0	6	0
HN	-40	32	-1	0	0	6	0	-72	78	0	0	0	6	0
KUEN	39	31	0	2	2	5	0	32	23	0	2	2	5	0
SHA	7	9	0	0	0	-3	0	1	5	0	0	0	-3	0
TBB	49	43	-1	2	2	3	0	15	10	-1	2	2	3	0
HDH	9	4	0	0	0	4	0	5	65	0	1	1	4	0
AA	14	10	0	1	1	0	0	-6	-9	0	2	2	0	0
BAD	5	5	0	0	0	0	0	-9	-9	0	0	0	0	0
KAsk	-11	63	0	1	1	8	0	10	82	0	1	1	9	0
KA	-11	63	0	1	1	8	0	10	82	0	1	1	9	0
RA	5	5	0	0	0	0	0	-9	-9	0	0	0	0	0
HDsk	-64	8	0	3	3	5	0	-37	33	0	2	2	4	0
MAsk	-64	8	0	3	3	5	0	-37	33	0	2	2	4	0
MOS	-11	4	0	1	1	-18	0	-46	-31	0	1	1	-18	0
HD	-64	8	0	3	3	5	0	-37	33	0	2	2	4	0
PFsk	31	8	0	3	3	15	0	50	23	0	4	4	15	0
CW	16	21	0	-2	-2	0	0	-5	48	0	-2	-2	0	-1
PF	31	8	0	3	3	15	0	50	23	0	4	4	15	0
FDS	-10	3	0	-3	-3	-5	-1	-23	39	0	-3	-3	-5	-1
FRsk	4	2	1	1	1	0	0	-15	-17	1	1	1	0	0
FR	4	2	1	1	1	0	0	-15	-17	1	1	1	0	0
EM	14	8	-2	3	3	3	0	10	4	-2	2	2	2	0

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
OG	13	12	-1	1	1	0	0	8	7	0	1	1	0	0
RW	-14	2	0	-3	-3	-9	-2	-17	-1	0	-3	-3	-10	0
VS	4	3	0	2	2	-3	0	-4	-6	0	2	2	-2	0
TUT	0	6	0	-2	-2	-1	0	-8	36	0	-2	-2	-1	0
KN	14	2	-1	5	5	2	0	-18	-30	-2	5	5	2	0
LOE	15	6	6	0	0	2	0	8	0	6	1	1	2	0
WT	-26	8	-1	6	6	-1	0	-13	20	0	6	6	-1	0
RT	17	14	0	1	1	1	0	4	48	-1	1	1	0	0
TUE	-37	30	-2	3	3	-4	0	-16	-10	-1	2	2	-5	0
BL	-32	1	0	-14	-14	-2	-2	-24	-15	0	-15	-15	-3	-1
ULsk	32	27	0	1	1	4	0	6	1	0	1	1	4	0
UL	32	27	0	1	1	4	0	6	1	0	1	1	4	0
BC	44	32	0	1	1	9	0	28	18	0	1	1	9	0
FN	16	7	-1	3	3	3	0	-5	-14	0	3	3	3	0
RV	8	3	5	0	0	0	0	3	-3	5	1	1	0	0
SIG	-49	12	0	2	2	0	0	-82	-20	0	2	2	0	0

%UAA: Percentage share of utilized agricultural area. pp: percentage points. NA-2: Crop rotation with four crop groups. NB-1: Cattle density is between 0.3 and 2.0 LU per hectares. NB-2: Cattle density is between 0.3 and 1.4 LU per hectares. NC-4: Regional typical pasture. NE-2: Greening of arable area in autumn. NE-3: Greening of set-aside area.

Table 5.1-12: Development of crop production area in NUTS3 regions in the scenario SUBshift70% (results from Section 3.2).

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
S	-4	0	0	0	-2	3	0	-2	0	0	0	0	0	0	1	0	-2	1	2	-22	0	0	0	-2	0	1	1	0
BB	-7	0	0	5	-14	6	0	0	0	-1	0	0	0	0	5	1	-1	1	3	-39	0	0	0	-3	0	1	2	0
ES	-6	-1	0	2	0	2	0	-1	0	0	0	0	0	0	2	0	-2	1	3	-23	0	0	0	0	1	3	-2	0
GP	-10	-1	-1	-1	5	3	0	0	0	0	0	0	0	0	1	0	-1	1	1	-24	0	0	0	0	1	2	-4	0
LB	-12	0	0	3	1	1	0	-1	0	0	0	0	0	0	1	2	-1	2	3	-26	0	0	0	-2	0	1	0	0
WN	-10	-1	0	1	4	5	0	-1	0	0	0	0	0	0	1	0	-1	1	2	-18	0	0	0	-2	0	8	-6	0
HNsk	-10	0	0	2	-3	1	0	-1	0	1	0	0	0	0	2	2	0	1	4	-24	0	0	0	-1	0	1	0	0
HN	-10	0	0	2	-3	1	0	-1	0	1	0	0	0	0	2	2	0	1	4	-24	0	0	0	-1	0	1	0	0
KUEN	-19	-1	0	2	10	4	0	-2	0	0	0	0	0	0	3	0	-2	1	4	-38	0	0	0	0	0	1	-1	0
SHA	-11	-1	-1	-5	4	5	0	-1	0	2	0	0	0	0	3	0	0	1	2	-42	0	0	0	0	-2	1	-4	0
TBB	-33	0	0	14	-6	4	0	0	0	2	0	0	0	0	10	1	-2	1	6	-55	0	0	0	-2	0	0	3	0
HDH	-22	0	-1	0	9	4	0	0	0	1	0	0	0	0	3	0	0	1	1	-36	0	0	0	-3	0	1	3	0
AA	-11	0	0	3	-8	5	0	0	0	0	0	0	0	0	3	0	0	1	2	-34	0	0	0	-4	0	1	1	0
BAD	-7	0	-1	1	0	3	0	-9	0	1	0	0	0	0	0	1	-1	1	8	-14	0	0	0	-3	0	1	2	0
KAsk	-8	0	-2	1	-2	2	0	-4	0	0	0	0	0	0	2	2	-1	1	7	-25	0	0	0	-3	0	0	3	0
KA	-8	0	-2	1	-2	2	0	-4	0	0	0	0	0	0	2	2	-1	1	7	-25	0	0	0	-3	0	0	3	0
RA	-7	0	-1	1	0	3	0	-9	0	1	0	0	0	0	0	1	-1	1	8	-14	0	0	0	-3	0	1	2	0
HDsk	-3	0	1	4	-18	4	0	-2	0	0	0	0	0	0	2	2	0	1	6	-30	0	0	0	-2	1	1	2	0
MAsk	-3	0	1	4	-18	4	0	-2	0	0	0	0	0	0	2	2	0	1	6	-30	0	0	0	-2	1	1	2	0
MOS	-36	0	0	15	-18	5	0	-1	0	0	0	0	0	0	10	0	-2	1	7	-64	0	0	0	0	1	1	1	0
HD	-3	0	1	4	-18	4	0	-2	0	0	0	0	0	0	2	2	0	1	6	-30	0	0	0	-2	1	1	2	0
PFsk	-4	1	0	2	-15	7	0	-1	0	0	0	0	0	0	4	0	-6	1	4	-31	0	0	0	-6	0	9	-3	0
CW	-7	0	-1	0	-12	6	0	0	0	0	0	0	0	0	2	0	0	1	4	-34	0	0	0	-4	0	2	1	0
PF	-4	1	0	2	-15	7	0	-1	0	0	0	0	0	0	4	0	-6	1	4	-31	0	0	0	-6	0	9	-3	0

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
FDS	-10	-1	-1	2	-17	6	0	0	0	0	0	0	0	0	5	0	0	0	4	-43	0	0	0	-2	0	2	-2	0
FRsk	-1	0	0	0	-5	1	0	-5	0	0	0	0	0	0	0	1	0	0	3	-11	0	0	0	-6	0	4	2	0
FR	-1	0	0	0	-5	1	0	-5	0	0	0	0	0	0	0	1	0	0	3	-11	0	0	0	-6	0	4	2	0
EM	-5	0	0	0	2	2	0	-8	0	0	0	0	0	0	0	0	0	0	4	-5	0	0	0	-4	0	0	4	0
OG	-8	0	0	1	4	1	0	-8	0	0	0	0	0	0	0	1	0	1	5	-7	0	0	0	-4	0	2	3	0
RW	-22	0	0	-3	7	6	0	0	0	0	0	0	0	0	6	0	-1	0	0	-42	0	0	0	0	-6	2	-10	0
VS	0	0	0	4	-7	4	0	0	0	1	0	0	0	0	6	0	-2	0	3	-20	0	0	0	0	-7	1	-9	0
TUT	-5	0	0	4	-2	4	0	0	0	0	0	0	0	0	5	0	-2	1	4	-21	0	0	0	0	-9	1	-11	0
KN	-7	0	0	6	-13	2	0	-1	0	0	0	0	0	0	4	0	-2	2	4	-32	0	0	0	-2	1	1	2	0
LOE	-3	0	0	2	0	1	0	-3	0	0	0	0	0	0	0	0	-2	1	2	-7	0	0	0	-1	0	-2	2	0
WT	-4	-1	0	3	-9	3	0	0	0	0	0	0	0	0	1	1	0	1	2	-21	0	0	0	0	3	2	3	0
RT	-9	0	0	2	-5	5	0	0	0	1	0	0	0	0	3	0	-3	0	3	-27	0	0	0	-3	0	0	3	0
TUE	-5	0	0	-1	-2	0	0	-1	0	1	0	0	0	0	1	-1	0	1	5	-46	0	0	0	0	-8	4	-13	0
BL	0	0	0	2	-5	6	0	0	0	0	0	0	0	0	4	0	-1	1	2	-20	0	0	0	0	-23	0	-29	0
ULsk	-16	0	0	7	-6	4	0	-1	0	1	0	0	0	0	6	0	-1	1	2	-48	0	0	0	-2	0	1	1	0
UL	-16	0	0	7	-6	4	0	-1	0	1	0	0	0	0	6	0	-1	1	2	-48	0	0	0	-2	0	1	1	0
BC	-19	0	0	3	6	4	0	-1	0	0	0	0	0	0	3	0	-2	1	2	-35	0	0	0	-1	0	5	-3	0
FN	-5	0	0	2	-5	1	0	-2	0	0	0	0	0	0	1	3	-2	1	2	-16	0	0	0	-5	0	1	4	0
RV	-2	0	0	-1	-1	1	0	-1	0	0	0	0	0	0	1	0	0	0	1	-9	0	0	0	-2	0	-2	3	0
SIG	-10	0	0	8	-12	5	0	0	0	1	0	0	0	0	5	0	-4	2	3	-42	0	0	0	-2	0	1	1	0

pp: percentage points.

Table 5.1-13: Development of economic, production and environmental indicator values in NUTS3 regions in the scenario EmaizeSM (results from Section 3.3).

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	% [t]	% [t]	% [t]	%	%	%	%	%[v]	%[v]	%	pp[o]
S	-41	-34	-25	-8	-3	-10	4	0	0	0	2	2	-2	0	1	1	0	0	0	3	23	-4	-13	-16	-9	8	-25	-15	-7	-1
BB	-31	-7	-64	-32	-34	-16	6	0	0	0	5	3	-3	0	1	2	0	0	0	3	11	-5	-29	-22	12	6	-37	135	166	-6
ES	-46	-47	-9	-25	-20	-4	-1	-1	0	0	2	3	0	1	3	-2	0	0	0	1	13	12	36	-11	5	3	-18	122	134	7
GP	-57	-81	11	-14	-5	-5	4	0	0	0	2	1	1	-2	2	-5	0	0	0	1	13	6	-6	-21	-9	-1	-35	61	68	9
LB	-16	8	-108	-21	-22	-18	10	1	0	0	2	3	-2	0	2	-1	0	0	0	2	12	-3	-32	-16	3	4	-26	74	92	-5
WN	-50	-62	5	-17	-12	-7	4	0	0	0	1	2	-1	0	8	-7	0	0	0	1	12	-3	5	-20	-5	3	-37	75	90	8
HNsk	-16	12	-155	-27	-30	-15	5	1	0	0	4	4	-1	0	1	0	0	0	0	2	11	-4	10	-14	6	4	-19	93	109	-5
HN	-16	12	-155	-27	-30	-15	5	1	0	0	4	4	-1	0	1	0	0	0	0	2	11	-4	10	-14	6	4	-19	93	109	-5
KUEN	-29	-4	-82	-10	-7	-9	4	-1	0	0	4	4	2	0	1	-3	0	0	0	1	11	0	18	-18	15	5	-38	96	127	0
SHA	-33	-29	-6	-4	1	-7	3	0	0	0	4	2	2	-2	1	-4	0	0	0	4	13	-6	-3	-14	2	5	-35	-13	3	4
TBB	-13	7	-88	-12	-12	-22	6	-1	0	0	11	6	-1	0	0	1	0	0	0	5	13	-8	0	-11	12	8	-21	-11	12	-4
HDH	-34	-20	-30	-16	-10	-14	5	0	0	0	4	1	-3	0	1	3	0	0	0	2	13	-5	-10	-27	2	3	-54	71	92	-3
AA	-41	-53	13	-15	-10	-12	5	1	0	0	4	2	-1	0	1	-1	0	0	0	4	13	-9	-1	-12	1	3	-31	-19	-6	4
BAD	-17	-8	-19	-26	-31	-5	-9	-1	0	0	3	8	-3	0	1	2	0	0	0	6	20	-7	9	-23	-11	10	-34	-3	8	-15
KAsk	-11	3	-58	-22	-28	-17	5	0	0	0	3	7	-2	0	0	2	0	0	0	6	13	-11	-14	-14	-5	8	-20	-29	-19	-12
KA	-11	3	-58	-22	-28	-17	5	0	0	0	3	7	-2	0	0	2	0	0	0	6	13	-11	-14	-14	-5	8	-20	-29	-19	-12
RA	-17	-8	-19	-26	-31	-5	-9	-1	0	0	3	8	-3	0	1	2	0	0	0	6	20	-7	9	-23	-11	10	-34	-3	8	-15
HDsk	-13	10	-99	-27	-33	-18	7	0	0	0	3	6	-1	0	1	0	0	0	0	2	11	-5	-52	-17	3	4	-27	76	96	-9
MAsk	-13	10	-99	-27	-33	-18	7	0	0	0	3	6	-1	0	1	0	0	0	0	2	11	-5	-52	-17	3	4	-27	76	96	-9
MOS	-27	2	-102	-17	-14	-14	-1	-1	0	0	8	7	0	0	1	-1	0	0	0	3	13	-2	43	-18	24	3	-32	133	167	-6
HD	-13	10	-99	-27	-33	-18	7	0	0	0	3	6	-1	0	1	0	0	0	0	2	11	-5	-52	-17	3	4	-27	76	96	-9
PFsk	-25	-23	3	-12	-5	-23	19	-5	0	0	4	4	-2	0	9	-7	0	0	0	7	23	-8	29	-5	0	10	-13	-63	-56	2
CW	-46	-60	13	-23	-14	-13	2	0	0	0	4	4	-4	1	2	3	0	0	0	3	23	-13	6	-15	-2	10	-35	-15	-3	5

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	% [t]	% [t]	% [t]	%	%	%	%	%[v]	%[v]	%	pp[o]
PF	-25	-23	3	-12	-5	-23	19	-5	0	0	4	4	-2	0	9	-7	0	0	0	7	23	-8	29	-5	0	10	-13	-63	-56	2
FDS	-45	-55	8	-18	-9	-15	1	0	0	0	7	5	-2	1	2	1	0	0	0	2	13	-10	0	-13	4	9	-30	-8	7	1
FRsk	-44	-69	29	-14	-9	-6	-3	0	0	0	2	3	-5	0	3	2	0	0	0	6	13	-8	3	-13	-10	7	-29	-25	-22	-2
FR	-44	-69	29	-14	-9	-6	-3	0	0	0	2	3	-5	0	3	2	0	0	0	6	13	-8	3	-13	-10	7	-29	-25	-22	-2
EM	-21	-32	31	-14	-12	-3	-4	-1	0	0	0	4	-4	0	2	2	0	0	0	5	12	-8	15	-13	-11	7	-26	-11	-11	-3
OG	-21	-24	16	-19	-19	-4	-7	0	0	0	2	5	-4	0	3	2	0	0	0	5	11	-8	20	-13	-8	10	-26	13	19	-4
RW	-43	-41	-7	-8	6	-2	0	0	0	0	8	0	0	-5	2	-7	0	0	0	1	13	3	12	-12	7	5	-25	80	86	0
VS	-73	-100	-4	-18	-2	3	0	-2	0	0	6	3	0	-10	1	-11	0	0	0	4	13	9	3	-6	1	3	-5	60	63	8
TUT	-74	-104	-1	-20	-2	2	0	-2	0	0	5	4	0	-9	1	-9	0	0	0	2	20	5	0	2	9	5	-3	44	48	7
KN	-32	-33	7	-16	-12	-15	7	0	0	0	4	4	2	0	3	-4	0	0	0	6	13	-8	8	-8	3	8	-24	-29	-15	-1
LOE	-54	-102	37	-15	-6	-2	5	-2	0	0	1	2	5	0	-7	2	0	0	0	7	13	-9	-1	-14	-12	7	-34	-50	-47	-2
WT	-56	-87	20	-17	-5	-6	3	1	0	0	2	2	2	0	2	-3	0	0	0	4	13	-2	-2	-4	5	5	-18	30	37	7
RT	-53	-70	9	-21	-11	-8	1	-3	0	0	5	3	-2	0	0	1	0	0	0	6	13	-6	6	-9	3	8	-31	32	41	4
TUE	-32	-24	-17	-17	-8	-7	7	0	0	0	4	5	0	-9	6	-16	0	0	0	2	14	-5	-17	-14	2	4	-23	-31	-12	-8
BL	-64	-94	10	-13	14	6	1	0	0	0	5	3	0	-14	0	-14	0	0	0	0	23	17	-2	14	20	1	25	111	111	10
ULsk	-25	-13	-29	-9	-6	-16	3	0	0	0	7	2	-2	0	1	1	0	0	0	4	13	-8	-4	-13	8	6	-29	-10	10	0
UL	-25	-13	-29	-9	-6	-16	3	0	0	0	7	2	-2	0	1	1	0	0	0	4	13	-8	-4	-13	8	6	-29	-10	10	0
BC	-30	-19	-25	-6	-2	-15	10	-2	0	0	4	2	-1	0	5	-4	0	0	0	4	13	-5	-2	-15	9	4	-37	45	66	3
FN	-40	-46	7	-15	-13	-11	5	-1	0	0	5	2	-2	0	1	1	0	0	0	4	13	0	3	-9	3	5	-21	47	59	3
RV	-83	-189	33	-16	-8	-2	3	0	0	0	1	1	4	0	-7	3	0	0	0	5	15	-1	-8	1	6	4	-5	11	15	5
SIG	-35	-32	-4	-8	-1	-9	4	-2	0	0	5	3	0	0	1	-1	0	0	0	5	13	-6	-3	-11	6	7	-29	-7	9	-2

m: Subsidy. n: Total gross margin. o: Percent share of utilized agricultural area/percentage points of utilized agricultural area compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare. t: u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. vu: Percentage points difference from reference year. wv: Green house gas. xw: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. n.c.: not calculated.

Table 5.1-14: Development of potential AEM area in NUTS3 regions in the scenario EmaizeSM (results from Section 3.3).

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	pp	pp	pp	pp	pp	pp	pp
S	0	0	0	0	0	0	0	17	22	0	0	0	0	0
BB	38	39	0	0	0	0	0	11	82	0	0	0	0	0
ES	10	10	0	0	0	0	0	28	-22	0	0	0	0	0
GP	7	7	0	0	0	0	0	-1	0	0	0	0	0	0
LB	-19	60	0	0	0	0	0	10	89	0	0	0	0	0
WN	8	8	0	0	0	0	0	-11	-12	0	0	0	0	0
HNsk	-22	56	0	0	0	0	0	-54	102	0	0	0	0	0
HN	-22	56	0	0	0	0	0	-54	102	0	0	0	0	0
KUEN	29	29	0	0	0	0	0	22	22	0	0	0	0	0
SHA	23	23	0	0	0	0	0	17	19	0	0	0	0	0
TBB	34	34	0	0	0	0	0	0	2	0	0	0	0	0
HDH	25	25	0	0	0	0	0	21	85	0	0	0	0	0
AA	18	18	0	0	0	0	0	-1	-1	0	0	0	0	0
BAD	5	5	0	0	0	0	0	-9	-9	0	0	0	0	0
KAsk	-26	57	0	0	0	0	0	-5	77	0	0	0	0	0
KA	-26	57	0	0	0	0	0	-5	77	0	0	0	0	0
RA	5	5	0	0	0	0	0	-9	-9	0	0	0	0	0
HDsk	-28	54	0	0	0	0	0	-1	79	0	0	0	0	0
MAsk	-28	54	0	0	0	0	0	-1	79	0	0	0	0	0
MOS	35	34	0	0	0	0	0	0	-1	0	0	0	0	0
HD	-28	54	0	0	0	0	0	-1	79	0	0	0	0	0
PFsk	6	6	0	0	0	0	0	25	21	0	0	0	0	0
CW	2	3	0	0	0	0	0	-19	30	0	0	0	0	0
PF	6	6	0	0	0	0	0	25	21	0	0	0	0	0
FDS	3	4	0	0	0	0	0	-10	40	0	0	0	0	0
FRsk	3	3	0	0	0	0	0	-17	-17	0	0	0	0	0
FR	3	3	0	0	0	0	0	-17	-17	0	0	0	0	0
EM	2	2	0	0	0	0	0	-2	-2	0	0	0	0	0

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
OG	12	12	0	0	0	0	0	7	7	0	0	0	0	0
RW	16	16	0	0	0	0	0	13	13	0	0	0	0	0
VS	10	10	0	0	0	0	0	1	1	0	0	0	0	0
TUT	9	9	0	0	0	0	0	1	40	0	0	0	0	0
KN	30	30	0	0	0	0	0	-2	-1	0	0	0	0	0
LOE	4	4	0	0	0	0	0	-2	-2	0	0	0	0	0
WT	-10	33	0	0	0	0	0	3	45	0	0	0	0	0
RT	21	21	0	0	0	0	0	8	55	0	0	0	0	0
TUE	-21	45	0	0	0	0	0	1	5	0	0	0	0	0
BL	1	1	0	0	0	0	0	10	-15	0	0	0	0	0
ULsk	25	26	0	0	0	0	0	0	0	0	0	0	0	0
UL	25	26	0	0	0	0	0	0	0	0	0	0	0	0
BC	2	2	0	0	0	0	0	-13	-13	0	0	0	0	0
FN	6	6	0	0	0	0	0	-16	-15	0	0	0	0	0
RV	10	10	0	0	0	0	0	5	4	0	0	0	0	0
SIG	-24	41	0	0	0	0	0	-57	8	0	0	0	0	0

%UAA: Percentage share of utilized agricultural area. pp: percentage points. NA-2: Crop rotation with four crop groups. NB-1: Cattle density is between 0.3 and 2.0 LU per hectares. NB-2: Cattle density is between 0.3 and 1.4 LU per hectares. NC-4: Regional typical pasture. NE-2: Greening of arable area in autumn. NE-3: Greening of set-aside area.

Table 5.1-15: Development of crop production area in NUTS3 regions in the scenario EmaizeSM (results from Section 3.3).

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
S	0	0	0	0	-15	4	0	-2	5	0	0	0	0	0	1	0	-1	1	2	-28	0	0	0	-2	0	1	1	0
BB	-24	0	0	3	4	3	0	0	6	0	0	0	0	0	4	1	-1	1	3	-43	0	0	0	-3	0	1	2	0
ES	-3	-1	0	3	-6	3	0	-1	0	0	0	0	0	0	2	0	-2	1	3	-24	0	0	0	0	1	3	-2	0
GP	-10	-1	-1	-1	5	3	0	0	4	0	0	0	0	0	1	0	-1	1	1	-25	0	0	0	1	-2	2	-5	0
LB	-20	-1	0	3	0	1	0	-2	11	0	0	0	0	0	1	2	-1	2	3	-37	0	0	0	-2	0	2	-1	0
WN	-9	-1	0	1	-2	5	0	-1	5	0	0	0	0	0	1	0	-1	1	2	-22	0	0	0	-1	0	8	-7	0
HNsk	-15	0	0	2	-4	1	0	-1	6	1	0	0	0	0	2	2	0	1	4	-30	0	0	0	-1	0	1	0	0
HN	-15	0	0	2	-4	1	0	-1	6	1	0	0	0	0	2	2	0	1	4	-30	0	0	0	-1	0	1	0	0
KUEN	-21	-1	0	0	10	3	0	-2	7	0	0	0	0	0	4	0	-2	1	4	-43	0	0	0	2	0	1	-3	0
SHA	-12	-1	-1	-6	8	5	0	-1	4	1	0	0	0	0	3	0	0	1	2	-40	0	0	0	2	-2	1	-5	0
TBB	-18	0	0	5	-11	3	0	0	6	1	0	0	0	0	8	1	-2	1	6	-58	0	0	0	-1	0	0	1	0
HDH	-28	0	-1	-3	14	4	0	0	5	1	0	0	0	0	3	0	0	1	1	-40	0	0	0	-3	0	1	3	0
AA	-14	0	0	2	-3	5	0	0	5	0	0	0	0	0	3	0	0	1	2	-35	0	0	0	-1	0	1	-1	0
BAD	-7	0	-1	1	0	3	0	-9	0	1	0	0	0	0	1	1	-1	1	8	-15	0	0	0	-3	0	1	2	0
KAsk	-12	0	-4	0	-3	2	0	-5	10	0	0	0	0	0	2	2	-1	1	7	-33	0	0	0	-2	0	0	2	0
KA	-12	0	-4	0	-3	2	0	-5	10	0	0	0	0	0	2	2	-1	1	7	-33	0	0	0	-2	0	0	2	0
RA	-7	0	-1	1	0	3	0	-9	0	1	0	0	0	0	1	1	-1	1	8	-15	0	0	0	-3	0	1	2	0
HDsk	-15	0	0	1	-4	2	0	-3	10	0	0	0	0	0	2	2	0	1	6	-35	0	0	0	-1	0	1	0	0
MAsk	-15	0	0	1	-4	2	0	-3	10	0	0	0	0	0	2	2	0	1	6	-35	0	0	0	-1	0	1	0	0
MOS	-17	0	0	5	-4	3	0	-1	0	0	0	0	0	0	8	0	-2	1	7	-46	0	0	0	0	0	1	-1	0
HD	-15	0	0	1	-4	2	0	-3	10	0	0	0	0	0	2	2	0	1	6	-35	0	0	0	-1	0	1	0	0
PFsk	-12	0	0	0	-15	4	0	-1	20	0	0	0	0	0	4	0	-7	2	4	-46	0	0	0	-2	0	9	-7	0
CW	-3	0	0	0	-17	6	0	0	2	0	0	0	0	0	3	0	0	1	4	-34	0	0	0	-4	1	2	3	0
PF	-12	0	0	0	-15	4	0	-1	20	0	0	0	0	0	4	0	-7	2	4	-46	0	0	0	-2	0	9	-7	0

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
FDS	-7	-1	-1	3	-17	6	0	0	1	0	0	0	0	0	6	0	0	0	5	-38	0	0	0	-2	1	2	1	0
FRsk	-1	0	0	0	-5	1	0	-4	1	0	0	0	0	0	0	1	0	0	3	-11	0	0	0	-5	0	3	2	0
FR	-1	0	0	0	-5	1	0	-4	1	0	0	0	0	0	0	1	0	0	3	-11	0	0	0	-5	0	3	2	0
EM	-6	0	0	0	1	2	0	-10	6	0	0	0	0	0	0	0	0	0	4	-8	0	0	0	-4	0	2	2	0
OG	-8	0	0	1	4	1	0	-7	0	0	0	0	0	0	0	1	0	1	5	-7	0	0	0	-4	0	3	2	0
RW	-23	0	0	-4	18	6	0	0	0	0	0	0	0	0	7	0	-1	0	0	-33	0	0	0	0	-5	2	-7	0
VS	-2	0	0	3	-1	4	0	0	0	1	0	0	0	0	6	0	-2	0	3	-17	0	0	0	0	-10	1	-11	0
TUT	-4	0	0	4	-2	4	0	0	0	0	0	0	0	0	5	0	-2	1	4	-19	0	0	0	0	-9	1	-9	0
KN	-13	0	0	1	-4	2	0	-1	8	0	0	0	0	0	4	0	-2	2	4	-34	0	0	0	2	0	3	-4	0
LOE	-4	0	0	2	0	1	0	-4	9	0	0	0	0	0	0	0	-2	1	2	-9	0	0	0	5	0	-7	2	0
WT	-6	0	0	2	-3	3	0	0	3	0	0	0	0	0	1	1	0	1	2	-20	0	0	0	2	0	2	-3	0
RT	-10	0	0	2	-5	5	0	0	1	1	0	0	0	0	4	0	-3	0	3	-27	0	0	0	-2	0	0	1	0
TUE	-5	0	0	-1	0	0	0	-1	9	2	0	0	0	0	2	0	-1	1	5	-42	0	0	0	0	-9	6	-16	0
BL	1	0	0	2	-5	8	0	0	1	0	0	0	0	0	4	0	-1	1	3	-17	0	0	0	0	-14	0	-14	0
ULsk	-18	0	0	6	-7	4	0	-1	4	1	0	0	0	0	7	0	-1	1	2	-52	0	0	0	-2	0	1	1	0
UL	-18	0	0	6	-7	4	0	-1	4	1	0	0	0	0	7	0	-1	1	2	-52	0	0	0	-2	0	1	1	0
BC	-20	0	0	3	-1	4	0	-1	11	0	0	0	0	0	3	0	-2	0	2	-44	0	0	0	-1	0	5	-4	0
FN	-6	0	0	0	-5	1	0	-2	7	0	0	0	0	0	1	3	-2	1	2	-20	0	0	0	-2	0	1	1	0
RV	-2	0	0	-1	1	1	0	-1	4	0	0	0	0	0	1	0	0	0	1	-9	0	0	0	4	0	-7	3	0
SIG	-14	0	0	4	-4	5	0	0	4	1	0	0	0	0	5	0	-4	2	3	-41	0	0	0	0	0	1	-1	0

%UAA: Percent share of utilized agricultural area.

Table 5.1-16: Development of economic, production and environmental indicator values in NUTS3 regions in the scenario EmaizeWW (results from Section 3.3).

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	% [t]	% [t]	% [t]	%	%	%	%	%[v]	%[v]	%	pp[o]
S	-43	-33	-35	-11	-6	-4	-2	0	0	0	2	2	-2	0	1	1	0	0	0	3	23	-6	-14	-11	-2	10	-20	-3	7	3
BB	-32	-6	-70	-33	-35	-57	51	-2	0	0	3	3	-3	0	1	2	0	0	0	2	11	-3	-41	-26	11	5	-42	151	183	-8
ES	-46	-47	-9	-27	-23	-29	36	-4	0	0	0	3	5	0	4	-9	0	0	0	1	13	10	31	-8	8	3	-15	120	133	8
GP	-58	-80	8	-13	-3	-9	14	0	0	0	1	1	6	-2	3	-10	0	0	0	0	13	9	-2	-20	-7	-1	-32	84	91	10
LB	-17	10	-128	-22	-23	-52	47	-1	0	0	2	3	-2	0	5	-4	0	0	0	1	12	-2	-14	-18	6	3	-30	96	117	-7
WN	-51	-60	0	-17	-11	-26	25	-1	0	0	0	2	1	0	5	-6	0	0	0	2	12	-2	10	-16	-1	3	-30	93	109	9
HNsk	-17	13	-170	-28	-31	-59	51	-1	0	0	3	4	-1	0	4	-3	0	0	0	1	11	-4	6	-16	7	3	-21	106	123	-6
HN	-17	13	-170	-28	-31	-59	51	-1	0	0	3	4	-1	0	4	-3	0	0	0	1	11	-4	6	-16	7	3	-21	106	123	-6
KUEN	-30	-3	-91	-10	-6	-43	44	-4	0	0	2	4	2	0	3	-5	0	0	0	1	11	4	16	-19	15	5	-40	112	143	-1
SHA	-34	-28	-11	-2	4	-4	-1	0	0	0	5	2	1	-2	1	-3	0	0	0	4	13	-3	-2	-17	0	4	-38	1	15	4
TBB	-13	8	-97	-12	-12	-17	0	-1	0	0	11	6	-1	0	0	1	0	0	0	5	13	-8	-1	-12	13	8	-23	3	26	-5
HDH	-35	-19	-35	-13	-5	-33	27	-1	0	0	2	1	-3	0	1	3	0	0	0	2	13	-4	-3	-31	2	3	-60	85	106	-4
AA	-42	-51	9	-13	-7	-8	0	1	0	0	4	2	-2	0	1	1	0	0	0	3	13	-8	1	-11	3	2	-29	2	14	4
BAD	-17	-8	-20	-27	-32	-13	1	-2	0	0	3	8	-3	0	2	1	0	0	0	6	20	-8	7	-22	-10	10	-33	-2	9	-14
KAsk	-12	5	-72	-25	-31	-9	-4	0	0	0	4	7	-2	0	0	2	0	0	0	6	13	-8	-10	-15	-2	7	-21	-9	3	-12
KA	-12	5	-72	-25	-31	-9	-4	0	0	0	4	7	-2	0	0	2	0	0	0	6	13	-8	-10	-15	-2	7	-21	-9	3	-12
RA	-17	-8	-20	-27	-32	-13	1	-2	0	0	3	8	-3	0	2	1	0	0	0	6	20	-8	7	-22	-10	10	-33	-2	9	-14
HDsk	-14	12	-114	-29	-35	-55	48	-1	0	0	1	6	-1	0	2	-2	0	0	0	2	11	-4	-49	-18	6	3	-28	94	116	-9
MAsk	-14	12	-114	-29	-35	-55	48	-1	0	0	1	6	-1	0	2	-2	0	0	0	2	11	-4	-49	-18	6	3	-28	94	116	-9
MOS	-27	2	-102	-17	-14	-52	45	-4	0	0	5	7	2	0	2	-4	0	0	0	3	13	-2	43	-18	24	3	-33	133	167	-6
HD	-14	12	-114	-29	-35	-55	48	-1	0	0	1	6	-1	0	2	-2	0	0	0	2	11	-4	-49	-18	6	3	-28	94	116	-9
PFsk	-27	-19	-16	-18	-13	-5	-1	-5	0	0	5	4	-3	0	14	-11	0	0	0	6	23	-6	26	-4	9	9	-10	0	12	2
CW	-46	-59	12	-27	-19	-11	0	0	0	0	4	4	-4	1	2	3	0	0	0	4	23	-16	6	-11	3	11	-29	-10	3	6

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	% [t]	% [t]	% [t]	%	%	%	%	%[v]	%[v]	%	pp[o]
PF	-27	-19	-16	-18	-13	-5	-1	-5	0	0	5	4	-3	0	14	-11	0	0	0	6	23	-6	26	-4	9	9	-10	0	12	2
FDS	-45	-55	6	-21	-13	-14	0	0	0	0	7	5	-2	2	2	1	0	0	0	2	13	-13	3	-9	9	10	-23	-5	11	2
FRsk	-44	-68	27	-15	-10	-5	-4	0	0	0	2	3	-5	0	3	2	0	0	0	6	13	-8	3	-11	-7	7	-26	-20	-16	-1
FR	-44	-68	27	-15	-10	-5	-4	0	0	0	2	3	-5	0	3	2	0	0	0	6	13	-8	3	-11	-7	7	-26	-20	-16	-1
EM	-21	-30	28	-15	-12	-7	2	-2	0	0	0	4	-4	0	2	1	0	0	0	4	12	-7	15	-14	-11	7	-26	-4	-3	-4
OG	-21	-24	17	-18	-19	-17	8	-2	0	0	2	5	-4	0	4	1	0	0	0	5	11	-7	20	-14	-9	10	-28	12	18	-5
RW	-43	-41	-7	-5	11	-9	13	0	0	0	7	0	3	-6	2	-11	0	0	0	1	13	5	11	-15	3	5	-31	82	88	-1
VS	-73	-100	-4	-18	-1	2	4	-2	0	0	6	3	0	-13	1	-14	0	0	0	4	13	10	3	-6	1	3	-5	63	66	8
TUT	-74	-104	-1	-20	-1	1	2	-2	0	0	5	4	0	-10	1	-11	0	0	0	2	20	6	1	2	9	5	-2	47	51	7
KN	-33	-31	-1	-16	-11	-11	-1	0	0	0	6	4	-2	0	2	0	0	0	0	5	13	-5	7	-7	6	7	-22	0	13	-1
LOE	-55	-99	32	-17	-8	0	-3	-1	0	0	1	2	-1	0	-1	1	0	0	0	7	13	-3	-2	-6	-3	6	-20	-9	-6	1
WT	-57	-87	18	-17	-4	-7	8	1	0	0	2	2	5	0	2	-6	0	0	0	3	13	0	0	-2	7	5	-14	49	55	8
RT	-53	-69	8	-21	-10	-11	7	-4	0	0	4	3	0	0	0	-1	0	0	0	6	13	-5	6	-8	4	8	-28	42	50	5
TUE	-34	-22	-27	-15	-4	-5	-1	0	0	0	5	7	0	-6	3	-10	0	0	0	0	14	0	-19	-16	2	2	-25	3	19	-10
BL	-64	-93	9	-15	11	7	8	0	0	0	5	2	0	-21	0	-21	0	0	0	0	23	14	0	15	22	1	28	116	117	10
ULsk	-26	-12	-34	-9	-4	-12	-1	0	0	0	7	2	-2	0	1	1	0	0	0	3	13	-8	-1	-14	9	6	-30	2	22	0
UL	-26	-12	-34	-9	-4	-12	-1	0	0	0	7	2	-2	0	1	1	0	0	0	3	13	-8	-1	-14	9	6	-30	2	22	0
BC	-31	-18	-34	-6	-2	-29	26	-4	0	0	2	2	-1	0	5	-4	0	0	0	3	13	-3	-6	-15	12	3	-38	73	94	3
FN	-41	-44	1	-16	-13	-22	20	-4	0	0	3	2	-2	0	2	0	0	0	0	4	13	1	10	-7	7	4	-16	72	85	4
RV	-84	-187	31	-14	-7	-3	6	0	0	0	1	1	5	0	-8	3	0	0	0	5	15	3	-9	3	8	4	2	46	48	6
SIG	-35	-31	-7	-7	-1	-7	0	-2	0	0	5	3	-1	0	1	0	0	0	0	5	13	-5	1	-11	7	7	-28	8	23	-2

m: Subsidy. n: Total gross margin. o: Percent share of utilized agricultural area/percentage points of utilized agricultural area compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare. t: u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. vu: Percentage points difference from reference year. wv: Green house gas. xw: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. n.c.: not calculated.

Table 5.1-17: Development of potential AEM area in NUTS3 regions in the scenario EmaizeWW (results from Section 3.3).

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	pp	pp	pp	pp	pp	pp	pp
S	47	42	0	0	6	5	0	65	64	0	0	6	5	0
BB	-12	19	12	0	0	-43	0	-39	62	12	0	0	-42	0
ES	-28	10	1	-7	-7	-24	0	-9	-23	1	-7	-7	-24	0
GP	16	29	0	-5	-5	-4	0	7	22	0	-5	-5	-4	0
LB	-107	9	3	-3	-3	-34	0	-77	38	3	-3	-3	-34	0
WN	-8	9	-3	2	2	-18	0	-28	-12	-3	2	2	-17	0
HNsk	-125	0	2	-3	-3	-44	0	-156	46	3	-3	-3	-44	0
HN	-125	0	2	-3	-3	-44	0	-156	46	3	-3	-3	-44	0
KUEN	-37	0	2	-2	-2	-34	0	-44	-7	2	-2	-2	-35	0
SHA	29	24	0	1	1	4	0	23	19	0	1	1	3	0
TBB	40	35	0	0	0	5	0	6	2	-1	0	0	5	0
HDH	6	27	0	0	0	-22	0	2	87	0	0	0	-21	0
AA	26	19	0	1	1	3	0	7	0	0	2	2	4	0
BAD	-6	3	1	-1	-1	-8	0	-20	-11	1	-1	-1	-8	0
KAsk	-13	63	0	0	0	8	0	8	82	0	1	1	8	0
KA	-13	63	0	0	0	8	0	8	82	0	1	1	8	0
RA	-6	3	1	-1	-1	-8	0	-20	-11	1	-1	-1	-8	0
HDsk	-111	9	2	-1	-1	-37	0	-84	34	1	-2	-2	-37	0
MAsk	-111	9	2	-1	-1	-37	0	-84	34	1	-2	-2	-37	0
MOS	-23	22	1	-3	-3	-40	0	-58	-13	1	-3	-3	-40	0
HD	-111	9	2	-1	-1	-37	0	-84	34	1	-2	-2	-37	0
PFsk	70	46	15	-5	-5	18	0	89	61	15	-5	-5	18	0
CW	5	3	0	0	0	3	0	-17	30	0	0	0	2	-1
PF	70	46	15	-5	-5	18	0	89	61	15	-5	-5	18	0
FDS	5	4	0	1	1	1	0	-8	40	0	1	1	1	0
FRsk	11	9	0	0	0	1	0	-9	-10	0	0	0	1	0
FR	11	9	0	0	0	1	0	-9	-10	0	0	0	1	0
EM	-1	3	0	0	0	-3	0	-5	-2	0	-1	-1	-4	0

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	pp	pp	pp	pp	pp	pp	pp
OG	-14	0	1	-1	-1	-13	0	-19	-5	2	-1	-1	-13	0
RW	10	27	0	-5	-5	-7	-1	7	24	0	-5	-5	-8	0
VS	18	25	0	-3	-3	-1	0	9	16	0	-3	-3	-1	0
TUT	13	16	0	-2	-2	0	0	5	47	0	-1	-1	0	0
KN	35	24	-1	4	4	4	0	3	-8	-1	4	4	4	0
LOE	13	6	6	-1	-1	1	0	6	0	7	0	0	2	0
WT	-18	32	0	-3	-3	-1	0	-5	44	1	-3	-3	-1	0
RT	35	41	0	-2	-2	-3	0	22	75	0	-2	-2	-3	0
TUE	-19	40	-10	6	6	3	2	3	0	-9	6	6	3	2
BL	4	17	0	-6	-6	2	-1	13	2	0	-7	-7	1	-1
ULsk	30	26	0	0	0	4	0	5	0	0	1	1	4	0
UL	30	26	0	0	0	4	0	5	0	0	1	1	4	0
BC	7	22	0	0	0	-15	0	-8	7	0	0	0	-15	0
FN	-11	1	1	-1	-1	-11	0	-33	-20	1	-1	-1	-11	0
RV	0	3	-1	0	0	-1	0	-4	-3	-1	0	0	-1	0
SIG	-28	32	0	1	1	3	0	-61	0	0	1	1	3	0

%UAA: Percentage share of utilized agricultural area. pp: percentage points. NA-2: Crop rotation with four crop groups. NB-1: Cattle density is between 0.3 and 2.0 LU per hectares. NB-2: Cattle density is between 0.3 and 1.4 LU per hectares. NC-4: Regional typical pasture. NE-2: Greening of arable area in autumn. NE-3: Greening of set-aside area.

Table 5.1-18: Development of crop production area in NUTS3 regions in the scenario EmaizeWW (results from Section 3.3).

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
S	-5	0	0	0	-2	3	0	-2	0	0	0	0	0	0	1	0	-2	1	2	-23	0	0	0	-2	0	1	1	0
BB	-50	-1	-1	1	-8	3	0	-1	52	-1	0	0	0	0	3	1	-3	1	3	-75	0	0	0	-3	0	1	2	0
ES	-22	-3	-1	0	-3	0	0	-3	38	0	0	0	0	0	1	0	-4	0	3	-38	0	0	0	5	0	4	-9	0
GP	-16	-2	-1	-3	11	1	0	0	14	0	0	0	0	0	0	0	-1	1	1	-29	0	0	0	6	-2	3	-10	0
LB	-42	-2	0	0	-9	0	0	-4	51	0	0	0	0	0	0	2	-2	1	3	-50	0	0	0	-2	0	5	-4	0
WN	-22	-3	-1	-4	0	5	0	-3	28	0	0	0	0	0	0	0	-2	1	2	-35	0	0	0	1	0	5	-6	0
HNsk	-42	-1	-1	0	-17	1	0	-4	56	1	0	0	0	0	1	2	-1	0	4	-44	0	0	0	-1	0	4	-3	0
HN	-42	-1	-1	0	-17	1	0	-4	56	1	0	0	0	0	1	2	-1	0	4	-44	0	0	0	-1	0	4	-3	0
KUEN	-41	-3	0	-5	4	2	0	-4	48	0	0	0	0	0	1	0	-4	0	4	-74	0	0	0	2	0	3	-5	0
SHA	-11	-1	-1	-4	8	5	0	-1	0	2	0	0	0	0	4	0	0	1	2	-36	0	0	0	1	-2	1	-4	0
TBB	-15	0	0	6	-10	3	0	0	0	1	0	0	0	0	9	1	-2	1	6	-53	0	0	0	-1	0	0	1	0
HDH	-46	-1	-2	-7	19	4	0	0	27	1	0	0	0	0	1	0	-1	1	1	-61	0	0	0	-3	0	1	3	0
AA	-12	0	0	2	-3	5	0	0	0	0	0	0	0	0	3	0	0	1	2	-31	0	0	0	-2	0	1	1	0
BAD	-11	0	-4	0	0	3	0	-12	13	1	0	0	0	0	1	1	-1	1	8	-23	0	0	0	-3	0	2	1	0
KAsk	-8	0	-2	1	-2	2	0	-4	0	0	0	0	0	0	2	2	-1	1	7	-25	0	0	0	-2	0	0	2	0
KA	-8	0	-2	1	-2	2	0	-4	0	0	0	0	0	0	2	2	-1	1	7	-25	0	0	0	-2	0	0	2	0
RA	-11	0	-4	0	0	3	0	-12	13	1	0	0	0	0	1	1	-1	1	8	-23	0	0	0	-3	0	2	1	0
HDsk	-38	-2	-2	-1	-13	2	0	-7	55	0	0	0	0	0	1	1	-1	0	6	-50	0	0	0	-1	0	2	-2	0
MAsk	-38	-2	-2	-1	-13	2	0	-7	55	0	0	0	0	0	1	1	-1	0	6	-50	0	0	0	-1	0	2	-2	0
MOS	-44	-1	-1	2	-10	3	0	-2	46	0	0	0	0	0	5	0	-4	0	7	-86	0	0	0	2	0	2	-4	0
HD	-38	-2	-2	-1	-13	2	0	-7	55	0	0	0	0	0	1	1	-1	0	6	-50	0	0	0	-1	0	2	-2	0
PFsk	-8	1	0	1	-3	4	0	-1	0	0	0	0	0	0	4	1	-6	1	4	-28	0	0	0	-3	0	14	-11	0
CW	-4	0	0	1	-17	9	0	0	0	0	0	0	0	0	3	0	0	1	4	-31	0	0	0	-4	1	2	3	0
PF	-8	1	0	1	-3	4	0	-1	0	0	0	0	0	0	4	1	-6	1	4	-28	0	0	0	-3	0	14	-11	0

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
FDS	-7	-1	-1	4	-17	6	0	0	0	0	0	0	0	0	6	0	0	0	5	-38	0	0	0	-2	2	2	1	0
FRsk	-2	0	0	0	-4	1	0	-4	0	0	0	0	0	0	0	1	0	0	3	-10	0	0	0	-5	0	3	2	0
FR	-2	0	0	0	-4	1	0	-4	0	0	0	0	0	0	0	1	0	0	3	-10	0	0	0	-5	0	3	2	0
EM	-9	-1	0	-1	2	2	0	-17	19	0	0	0	0	0	0	0	-1	-1	4	-4	0	0	0	-4	0	2	1	0
OG	-18	-1	0	0	2	1	0	-17	26	0	0	0	0	0	0	1	-1	0	5	-10	0	0	0	-4	0	4	1	0
RW	-28	0	0	-4	17	6	0	0	13	0	0	0	0	0	6	0	-1	0	0	-40	0	0	0	3	-6	2	-11	0
VS	-2	0	0	3	-1	4	0	0	4	1	0	0	0	0	6	0	-2	0	3	-18	0	0	0	0	-13	1	-14	0
TUT	-4	0	0	4	-2	4	0	0	2	0	0	0	0	0	5	0	-2	1	4	-20	0	0	0	0	-10	1	-11	0
KN	-9	0	0	4	-7	2	0	-1	0	0	0	0	0	0	5	1	-2	2	4	-30	0	0	0	-2	0	2	0	0
LOE	-3	0	0	2	0	1	0	-3	0	0	0	0	0	0	0	0	-2	1	2	-7	0	0	0	-1	0	-1	1	0
WT	-8	0	0	2	-4	3	0	0	8	0	0	0	0	0	1	1	0	1	2	-21	0	0	0	5	0	2	-6	0
RT	-11	0	0	2	-6	5	0	0	7	1	0	0	0	0	4	0	-4	0	3	-30	0	0	0	0	0	0	-1	0
TUE	-3	0	0	0	-1	1	0	-1	0	2	0	0	0	0	3	0	-1	1	7	-39	0	0	0	0	-6	3	-10	0
BL	0	0	0	2	0	6	0	0	8	0	0	0	0	0	4	0	-1	1	2	-16	0	0	0	0	-21	0	-21	0
ULsk	-16	0	0	7	-6	4	0	-1	0	1	0	0	0	0	7	0	-1	1	2	-48	0	0	0	-2	0	1	1	0
UL	-16	0	0	7	-6	4	0	-1	0	1	0	0	0	0	7	0	-1	1	2	-48	0	0	0	-2	0	1	1	0
BC	-33	0	0	-3	4	4	0	-1	28	0	0	0	0	0	2	0	-3	-1	2	-59	0	0	0	-1	0	5	-4	0
FN	-14	-2	0	-1	-5	0	0	-5	25	0	0	0	0	0	0	2	-4	0	2	-29	0	0	0	-2	0	2	0	0
RV	-2	0	0	-1	-1	1	0	-1	7	0	0	0	0	0	1	0	0	0	1	-10	0	0	0	5	0	-8	3	0
SIG	-13	0	0	5	-4	5	0	0	0	1	0	0	0	0	5	0	-4	2	3	-39	0	0	0	-1	0	1	0	0

pp: percentage points.

Table 5.1-19: Development of economic, production and environmental indicator values in NUTS3 regions in the scenario Nred10% (results from Section 3.4).

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	%[t]	%[t]	%[t]	%	%	%	%	%[v]	%[v]	%	pp[o]
S	-51	-43	-34	-14	-9	-13	-3	-2	0	0	2	2	-4	4	-6	14	0	5	0	-1	15	-21	-40	-36	-21	-3	-47	-21	-6	-16
BB	-26	-16	-18	-24	-25	-19	0	-2	0	0	4	6	-6	6	-4	16	0	0	0	2	2	-23	-25	-38	-14	-1	-58	-32	-10	-18
ES	-45	-58	13	-23	-18	-13	-1	-3	0	0	1	6	0	9	-3	12	0	1	0	1	7	-12	-4	-22	-7	1	-42	-17	-3	-7
GP	-62	-95	18	-22	-13	-11	0	-1	0	0	1	2	0	3	-2	5	0	6	0	0	7	-12	-5	-27	-14	-2	-64	-34	-20	3
LB	-35	-16	-91	-20	-17	-28	-2	1	0	0	2	6	-4	3	-7	13	0	13	0	1	5	-31	-22	-13	5	0	-28	-27	-8	-14
WN	-50	-74	21	-18	-13	-11	-3	-2	0	0	1	4	-4	5	5	4	0	2	0	1	4	-19	-8	-21	-10	1	-52	-46	-34	-3
HNsk	-29	-8	-122	-18	-18	-23	-2	1	0	0	5	8	-2	7	-5	9	0	7	0	1	1	-22	-21	-24	-8	1	-35	-17	-3	-20
HN	-29	-8	-122	-18	-18	-23	-2	1	0	0	5	8	-2	7	-5	9	0	7	0	1	1	-22	-21	-24	-8	1	-35	-17	-3	-20
KUEN	-40	-27	-45	-9	-3	-22	-3	-3	0	0	2	8	0	6	-4	10	0	12	0	1	4	-29	-6	-20	5	1	-52	-31	-5	-15
SHA	-56	-52	-23	-9	0	-21	-2	0	0	0	2	4	0	13	-2	3	0	17	0	-2	5	-28	-5	-12	13	1	-53	-31	-4	-1
TBB	-23	0	-109	-18	-17	-31	0	-2	0	0	8	12	-2	3	-2	7	0	7	0	0	2	-27	-7	-25	9	1	-43	-23	9	-20
HDH	-43	-37	-16	-23	-17	-30	0	0	0	0	5	3	-6	4	-3	15	0	10	0	-3	3	-27	-13	-25	1	3	-70	-29	-5	-12
AA	-54	-68	6	-19	-13	-23	0	1	0	0	3	4	-4	13	-2	9	0	10	0	-3	3	-25	-5	-20	1	0	-64	-33	-13	1
BAD	-22	-16	-10	-34	-40	-16	-19	-3	0	0	3	19	-6	10	-3	13	0	5	0	4	13	-34	-12	-41	-28	5	-61	-51	-37	-39
KAsk	-17	-2	-64	-31	-37	-22	-7	-2	0	0	3	14	-4	6	-4	14	0	5	0	1	2	-32	-29	-34	-17	0	-45	-48	-31	-35
KA	-17	-2	-64	-31	-37	-22	-7	-2	0	0	3	14	-4	6	-4	14	0	5	0	1	2	-32	-29	-34	-17	0	-45	-48	-31	-35
RA	-22	-16	-10	-34	-40	-16	-19	-3	0	0	3	19	-6	10	-3	13	0	5	0	4	13	-34	-12	-41	-28	5	-61	-51	-37	-39
HDsk	-30	-13	-81	-25	-25	-29	-5	0	0	0	3	12	-2	4	-4	10	0	14	0	2	4	-37	-44	-15	3	1	-32	-37	-17	-20
MAsk	-30	-13	-81	-25	-25	-29	-5	0	0	0	3	12	-2	4	-4	10	0	14	0	2	4	-37	-44	-15	3	1	-32	-37	-17	-20
MOS	-29	-11	-60	-18	-14	-30	-1	-2	0	0	6	14	0	6	-2	8	0	6	0	1	4	-27	-6	-27	5	0	-53	-16	14	-17
HD	-30	-13	-81	-25	-25	-29	-5	0	0	0	3	12	-2	4	-4	10	0	14	0	2	4	-37	-44	-15	3	1	-32	-37	-17	-20
PFsk	-23	-23	13	-19	-17	-19	-2	-9	0	0	4	7	-6	13	5	14	0	0	0	3	16	-25	16	-24	-11	2	-39	-90	-75	-10
CW	-49	-64	11	-26	-18	-18	0	-1	0	0	2	7	-4	5	-3	12	0	2	0	-1	22	-25	-4	-26	-9	2	-60	-33	-16	-4

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	% [t]	% [t]	% [t]	%	%	%	%	%[v]	%[v]	%	pp[o]
PF	-23	-23	13	-19	-17	-19	-2	-9	0	0	4	7	-6	13	5	14	0	0	0	3	16	-25	16	-24	-11	2	-39	-90	-75	-10
FDS	-49	-60	6	-18	-7	-20	0	-1	0	0	5	8	-2	5	0	6	0	3	0	-3	5	-17	-6	-24	-3	3	-57	-23	-3	-9
FRsk	-42	-69	33	-17	-13	-14	-11	0	0	0	2	3	-10	11	17	3	0	0	0	-2	4	-24	14	-41	-33	1	-70	-60	-52	-16
FR	-42	-69	33	-17	-13	-14	-11	0	0	0	2	3	-10	11	17	3	0	0	0	-2	4	-24	14	-41	-33	1	-70	-60	-52	-16
EM	-27	-44	39	-15	-12	-6	-15	0	0	0	0	4	-8	5	-9	22	0	5	0	2	1	-24	-12	-31	-26	1	-55	-55	-51	-16
OG	-24	-32	25	-19	-18	-12	-14	0	0	0	2	10	-8	5	-7	20	0	2	0	3	1	-24	-16	-28	-20	4	-49	-47	-37	-16
RW	-59	-62	-9	-16	0	-18	0	-1	0	0	7	2	0	1	0	-2	0	13	0	0	7	-19	-3	-11	12	2	-38	-6	14	-8
VS	-70	-101	3	-20	-6	1	0	-2	0	0	6	3	0	-7	-5	-2	0	0	0	3	10	3	-5	-4	3	1	-17	22	28	6
TUT	-72	-105	2	-25	-8	-5	0	-4	0	0	5	7	0	-3	0	-2	0	0	0	2	18	-4	-1	-7	3	3	-23	4	12	3
KN	-41	-43	3	-22	-17	-25	-3	-3	0	0	4	8	-2	7	-3	12	0	8	0	3	5	-27	-4	-20	-2	2	-49	-55	-34	-12
LOE	-53	-102	38	-17	-8	-6	-6	-1	0	0	1	2	-2	9	6	3	0	0	0	3	7	-18	3	-32	-28	1	-65	-71	-65	-11
WT	-54	-92	28	-22	-13	-16	0	-1	0	0	1	4	0	11	-4	15	0	1	0	2	4	-20	-8	-22	-9	1	-57	-54	-39	0
RT	-52	-76	20	-30	-23	-24	0	-8	0	0	6	3	-6	16	-4	23	0	3	0	2	4	-28	-5	-35	-15	2	-79	-59	-38	-6
TUE	-46	-37	-28	-22	-10	-17	-2	-1	0	0	2	9	0	-2	0	-3	0	10	0	-2	8	-19	-46	-24	0	-3	-39	-46	-20	-21
BL	-62	-97	16	-19	4	4	0	0	0	0	5	4	0	-12	0	-12	0	0	0	0	22	6	-2	4	11	0	5	26	30	4
ULsk	-40	-26	-44	-14	-8	-26	-1	-1	0	0	4	5	-4	14	-1	8	0	12	0	-1	3	-28	-12	-25	6	1	-56	-23	6	-11
UL	-40	-26	-44	-14	-8	-26	-1	-1	0	0	4	5	-4	14	-1	8	0	12	0	-1	3	-28	-12	-25	6	1	-56	-23	6	-11
BC	-40	-37	-10	-9	-3	-23	-2	-4	0	0	3	4	-4	8	4	6	0	11	0	1	3	-27	-2	-15	6	0	-47	-48	-24	-7
FN	-34	-53	33	-15	-13	-13	-5	-3	0	0	5	4	-6	7	-8	21	0	0	0	3	5	-16	-16	-26	-18	1	-52	-64	-54	-7
RV	-82	-193	36	-17	-10	-10	-2	0	0	0	0	1	-2	9	7	4	0	0	0	-3	3	-14	5	-13	-6	2	-38	-61	-52	3
SIG	-53	-51	-17	-14	-4	-24	0	-6	0	0	3	7	-2	5	0	7	0	13	0	2	5	-26	-6	-15	11	0	-45	-30	-5	-15

m: Subsidy. n: Total gross margin. o: Percent share of utilized agricultural area/percentage points of utilized agricultural area compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare. t: u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. vu: Percentage points difference from reference year. wv: Green house gas. xw: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. n.c.: not calculated.

Table 5.1-20: Development of potential AEM area in NUTS3 regions in the scenario Nred10% (results from Section 3.4).

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	pp	pp	pp	pp	pp	pp	pp
S	11	0	-12	13	0	-3	0	29	22	-12	14	0	-3	0
BB	61	27	7	15	15	-4	3	34	70	7	15	15	-4	3
ES	22	5	-5	13	13	-7	3	40	-28	-6	14	14	-7	3
GP	38	27	-4	10	10	-7	1	29	20	-4	10	10	-7	1
LB	-64	7	-11	13	13	-11	3	-35	36	-11	13	13	-10	3
WN	48	30	-4	12	12	-4	2	29	10	-3	11	11	-3	2
HNsk	-25	46	-8	9	9	-8	4	-57	92	-8	9	9	-7	4
HN	-25	46	-8	9	9	-8	4	-57	92	-8	9	9	-7	4
KUEN	27	15	-5	13	13	-13	4	20	8	-5	13	13	-13	4
SHA	4	9	-3	7	7	-16	2	-1	4	-3	6	6	-17	2
TBB	44	39	-2	7	7	-11	6	11	6	-2	7	7	-12	6
HDH	10	3	-4	12	12	-15	1	5	64	-3	12	12	-15	1
AA	24	17	-3	10	10	-12	2	5	-2	-3	10	10	-12	2
BAD	21	3	-4	11	11	-11	11	8	-11	-4	11	11	-11	11
KAsk	-10	52	-4	12	12	-5	7	11	72	-4	12	12	-5	6
KA	-10	52	-4	12	12	-5	7	11	72	-4	12	12	-5	6
RA	21	3	-4	11	11	-11	11	8	-11	-4	11	11	-11	11
HDsk	-66	7	-4	10	10	-11	6	-39	32	-5	10	10	-12	6
MAsk	-66	7	-4	10	10	-11	6	-39	32	-5	10	10	-12	6
MOS	41	35	-3	9	9	-17	7	6	0	-3	9	9	-17	8
HD	-66	7	-4	10	10	-11	6	-39	32	-5	10	10	-12	6
PFsk	55	7	0	20	20	4	3	74	23	0	20	20	4	3
CW	12	2	-5	9	9	-6	3	-10	29	-5	9	9	-7	3
PF	55	7	0	20	20	4	3	74	23	0	20	20	4	3
FDS	28	22	-1	6	6	-7	3	15	59	-2	6	6	-7	3
FRsk	11	1	15	2	2	-8	0	-9	-18	14	2	2	-7	0
FR	11	1	15	2	2	-8	0	-9	-18	14	2	2	-7	0
EM	29	2	-11	20	20	-3	0	25	-2	-11	20	20	-3	0

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
OG	27	3	-10	18	18	-9	5	21	-1	-10	19	19	-8	5
RW	-5	2	-2	5	5	-16	1	-8	-1	-2	5	5	-16	2
VS	18	8	-6	9	9	-3	0	9	-1	-6	9	9	-2	0
TUT	10	1	-1	7	7	-6	3	2	31	-1	7	7	-6	4
KN	23	2	-5	16	16	-10	4	-8	-30	-6	16	16	-9	4
LOE	14	1	14	1	1	-5	0	7	-5	14	1	1	-4	0
WT	-20	0	-6	18	18	-9	2	-7	12	-5	18	18	-9	2
RT	27	1	-4	22	22	-14	0	13	35	-5	22	22	-15	0
TUE	-49	3	-6	13	13	-10	4	-27	-37	-5	13	13	-11	4
BL	5	1	0	3	3	-1	1	14	-15	0	3	3	-2	1
ULsk	30	28	-2	7	7	-12	3	5	3	-3	8	8	-13	2
UL	30	28	-2	7	7	-12	3	5	3	-3	8	8	-13	2
BC	15	2	-1	10	10	-9	2	0	-13	-1	11	11	-9	2
FN	38	6	-9	20	20	-2	2	16	-15	-9	20	20	-2	1
RV	10	3	14	1	1	-8	0	6	-3	14	2	2	-8	0
SIG	-60	2	-1	8	8	-15	4	-93	-30	-1	8	8	-15	3

%UAA: Percentage share of utilized agricultural area. pp: percentage points. NA-2: Crop rotation with four crop groups. NB-1: Cattle density is between 0.3 and 2.0 LU per hectares. NB-2: Cattle density is between 0.3 and 1.4 LU per hectares. NC-4: Regional typical pasture. NE-2: Greening of arable area in autumn. NE-3: Greening of set-aside area.

Table 5.1-21: Development of crop production area in NUTS3 regions in the scenario Nred10% (results from Section 3.4).

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
S	-8	0	0	0	-15	5	5	-3	0	1	0	0	0	0	0	0	-2	1	2	-36	0	0	0	-4	4	-6	14	0
BB	-35	0	0	2	9	6	0	0	0	1	0	0	0	0	3	1	-2	0	6	-47	0	0	0	-6	6	-4	16	0
ES	-9	-2	0	2	-6	3	0	-1	0	0	0	0	0	0	1	0	-3	0	6	-32	0	0	0	0	9	-3	12	0
GP	-22	-1	-1	-4	15	1	0	0	0	0	0	0	0	0	0	0	-2	1	2	-32	0	0	0	0	3	-2	5	0
LB	-21	0	0	4	-14	2	2	-2	0	0	0	0	0	0	1	2	-1	2	6	-49	0	0	0	-4	3	-7	13	0
WN	-18	-2	0	0	4	5	0	-3	0	1	0	0	0	0	0	0	-2	0	4	-25	0	0	0	-4	5	5	4	0
HNsk	-26	0	0	2	-1	1	0	-2	0	2	0	0	0	0	1	2	0	1	8	-37	0	0	0	-2	7	-5	9	0
HN	-26	0	0	2	-1	1	0	-2	0	2	0	0	0	0	1	2	0	1	8	-37	0	0	0	-2	7	-5	9	0
KUEN	-31	-2	0	-1	7	5	0	-3	0	0	0	0	0	0	1	0	-3	0	8	-56	0	0	0	0	6	-4	10	0
SHA	-18	-1	-1	-11	4	5	0	-2	0	1	0	0	0	0	1	0	0	1	4	-56	0	0	0	0	13	-2	2	0
TBB	-32	0	0	4	-6	4	0	0	0	2	0	0	0	0	5	1	-3	1	12	-70	0	0	0	-2	3	-2	7	0
HDH	-38	0	-1	-4	9	4	0	0	0	5	0	0	0	0	0	0	0	1	3	-55	0	0	0	-6	4	-3	15	0
AA	-26	-1	0	1	-3	5	0	0	0	1	0	0	0	0	1	0	0	1	4	-46	0	0	0	-4	13	-2	9	0
BAD	-18	0	0	0	0	3	0	-19	0	1	0	0	0	0	0	1	-2	1	19	-26	0	0	0	-6	10	-3	13	0
KAsk	-23	0	1	0	-1	2	0	-7	0	1	0	0	0	0	1	1	-2	0	14	-38	0	0	0	-4	6	-4	14	0
KA	-23	0	1	0	-1	2	0	-7	0	1	0	0	0	0	1	1	-2	0	14	-38	0	0	0	-4	6	-4	14	0
RA	-18	0	0	0	0	3	0	-19	0	1	0	0	0	0	0	1	-2	1	19	-26	0	0	0	-6	10	-3	13	0
HDsk	-17	0	1	2	-18	4	0	-5	0	0	0	0	0	0	1	1	0	1	12	-46	0	0	0	-2	4	-4	10	0
MAsk	-17	0	1	2	-18	4	0	-5	0	0	0	0	0	0	1	1	0	1	12	-46	0	0	0	-2	4	-4	10	0
MOS	-33	0	0	3	-3	4	0	-1	0	1	0	0	0	0	5	0	-3	1	14	-63	0	0	0	0	6	-2	8	0
HD	-17	0	1	2	-18	4	0	-5	0	0	0	0	0	0	1	1	0	1	12	-46	0	0	0	-2	4	-4	10	0
PFsk	-11	0	1	1	-15	4	0	-2	0	1	0	0	0	0	3	1	-8	0	7	-42	0	0	0	-6	13	5	14	0
CW	-14	0	0	0	-17	12	0	0	0	0	0	0	0	0	1	0	-1	1	7	-40	0	0	0	-4	5	-3	12	0
PF	-11	0	1	1	-15	4	0	-2	0	1	0	0	0	0	3	1	-8	0	7	-42	0	0	0	-6	13	5	14	0

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
FDS	-22	-1	-1	1	-5	6	0	0	0	0	0	0	0	0	4	0	-1	0	8	-45	0	0	0	-2	5	0	6	0
FRsk	-8	0	0	0	-5	1	0	-11	0	0	0	0	0	0	0	1	0	0	3	-19	0	0	0	-10	11	17	3	0
FR	-8	0	0	0	-5	1	0	-11	0	0	0	0	0	0	0	1	0	0	3	-19	0	0	0	-10	11	17	3	0
EM	-10	0	1	0	1	2	0	-15	0	0	0	0	0	0	0	0	0	0	4	-11	0	0	0	-8	5	-9	22	0
OG	-15	0	0	1	2	1	0	-14	0	0	0	0	0	0	0	1	0	1	10	-16	0	0	0	-8	5	-7	20	0
RW	-27	0	0	-3	7	6	0	0	0	0	0	0	0	0	6	0	-2	0	2	-49	0	0	0	0	1	0	-2	0
VS	-5	0	0	4	-1	4	0	0	0	1	0	0	0	0	6	0	-2	0	3	-19	0	0	0	0	-7	-5	-2	0
TUT	-3	0	0	5	-11	4	0	0	0	1	0	0	0	0	5	0	-3	0	7	-25	0	0	0	0	-3	0	-2	0
KN	-16	0	0	3	-13	2	0	-3	0	0	0	0	0	0	4	0	-3	1	8	-44	0	0	0	-2	7	-3	12	0
LOE	-8	0	0	2	-1	1	0	-6	0	0	0	0	0	0	0	0	-3	1	2	-13	0	0	0	-2	9	6	3	0
WT	-9	-1	0	2	-11	3	0	0	0	0	0	0	0	0	1	0	0	0	4	-30	0	0	0	0	11	-4	15	0
RT	-12	0	0	2	-20	6	0	0	0	3	0	0	0	0	3	0	-5	-3	3	-42	0	0	0	-6	16	-4	23	0
TUE	-3	0	0	-2	-10	0	0	-2	0	2	0	0	0	0	1	-1	-2	1	9	-53	0	0	0	0	-2	0	-3	0
BL	1	0	0	2	-5	6	0	0	0	0	0	0	0	0	4	0	-1	1	4	-19	0	0	0	0	-12	0	-12	0
ULsk	-33	0	0	6	-4	5	0	-1	0	1	0	0	0	0	4	0	-2	0	5	-65	0	0	0	-4	14	-1	8	0
UL	-33	0	0	6	-4	5	0	-1	0	1	0	0	0	0	4	0	-2	0	5	-65	0	0	0	-4	14	-1	8	0
BC	-26	0	0	1	-1	4	0	-2	0	0	0	0	0	0	2	0	-3	-1	4	-53	0	0	0	-4	8	4	6	0
FN	-9	0	0	1	-5	0	0	-5	0	1	0	0	0	0	1	3	-3	0	4	-21	0	0	0	-6	7	-8	21	0
RV	-5	-1	0	-4	0	0	0	-2	0	0	0	0	0	0	0	0	-1	1	1	-17	0	0	0	-2	9	7	4	0
SIG	-20	0	0	5	-15	5	0	0	0	1	0	0	0	0	3	0	-7	1	7	-57	0	0	0	-2	5	0	7	0

pp: percentage points.

Table 5.1-22: Development of economic, production and environmental indicator values in NUTS3 regions in the scenario Mandatory AEM (results from Section 3.5).

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	% [t]	% [t]	% [t]	%	%	%	%	%[v]	%[v]	%	pp[o]
S	-41	-35	-20	-9	-5	-2	-2	-3	0	0	0	2	-4	0	0	5	0	0	0	1	23	-3	-17	-19	-11	0	-25	-15	-6	-5
BB	-27	-15	-24	-20	-19	-15	0	1	0	0	9	3	-3	0	1	2	0	0	0	6	13	-9	2	-12	4	11	-24	-12	4	-2
ES	-45	-55	9	-19	-12	-3	-1	-1	0	0	2	3	0	0	3	-3	0	0	0	4	14	0	8	-10	0	8	-22	0	10	2
GP	-53	-85	22	-15	-7	-4	0	-1	0	0	1	1	0	3	2	1	0	0	0	-3	13	-4	-6	-22	-12	1	-46	-25	-14	6
LB	-16	-1	-58	-22	-23	-20	-1	0	0	0	2	3	-4	12	-6	21	0	0	0	-5	14	-29	-13	-18	0	6	-30	-38	-19	-7
WN	-47	-70	23	-14	-9	-6	-1	-2	0	0	0	2	-4	3	8	-1	0	0	0	0	13	-13	-5	-16	-8	8	-40	-36	-25	3
HNsk	-17	2	-92	-16	-17	-18	0	1	0	0	6	4	-2	5	-4	12	0	0	-5	-8	13	-13	-11	-20	-6	4	-27	-16	-4	-12
HN	-17	2	-92	-16	-17	-18	0	1	0	0	6	4	-2	5	-4	12	0	0	-5	-8	13	-13	-11	-20	-6	4	-27	-16	-4	-12
KUEN	-23	-12	-25	-6	-2	-12	-2	-3	0	0	4	4	0	9	1	8	0	0	0	-3	13	-16	-4	-21	1	5	-44	-30	-7	-7
SHA	-32	-30	-1	-7	-2	-14	-1	-1	0	0	2	2	0	11	1	11	0	0	0	-8	12	-20	-3	-14	9	3	-48	-36	-10	0
TBB	-11	8	-79	-16	-19	-30	0	-3	0	0	16	6	-2	10	0	12	0	0	-2	-10	13	-21	-2	-22	8	4	-35	-23	7	-13
HDH	-28	-25	-1	-20	-17	-23	0	-2	0	0	3	1	-6	13	1	20	0	0	0	-12	13	-24	-2	-20	4	3	-55	-37	-14	-10
AA	-43	-58	16	-22	-18	-26	0	-1	0	0	2	2	-4	16	1	19	0	0	0	-10	13	-32	-2	-13	8	1	-53	-48	-27	0
BAD	-14	-10	1	-25	-30	3	-16	-1	0	0	2	8	-3	0	2	1	0	0	0	5	20	-13	-4	-27	-23	10	-40	-36	-31	-18
KAsk	-11	3	-54	-24	-30	-9	-4	0	0	0	3	7	-3	0	-3	6	0	0	0	6	13	-13	-30	-17	-8	6	-23	-29	-19	-14
KA	-11	3	-54	-24	-30	-9	-4	0	0	0	3	7	-3	0	-3	6	0	0	0	6	13	-13	-30	-17	-8	6	-23	-29	-19	-14
RA	-14	-10	1	-25	-30	3	-16	-1	0	0	2	8	-3	0	2	1	0	0	0	5	20	-13	-4	-27	-23	10	-40	-36	-31	-18
HDsk	-12	1	-44	-16	-18	-14	-2	0	0	0	3	6	-2	5	-4	11	0	0	0	-1	13	-16	-20	-18	-6	4	-29	-30	-16	-11
MAsk	-12	1	-44	-16	-18	-14	-2	0	0	0	3	6	-2	5	-4	11	0	0	0	-1	13	-16	-20	-18	-6	4	-29	-30	-16	-11
MOS	-20	-5	-41	-16	-15	-24	-1	-2	0	0	8	7	0	11	-1	12	0	0	0	-3	13	-20	9	-22	6	3	-39	-12	15	-9
HD	-12	1	-44	-16	-18	-14	-2	0	0	0	3	6	-2	5	-4	11	0	0	0	-1	13	-16	-20	-18	-6	4	-29	-30	-16	-11
PFsk	-25	-23	4	-10	-2	-4	-1	-7	0	0	4	4	-4	0	17	-13	0	0	0	5	23	-8	46	-3	1	8	-10	-67	-60	2
CW	-46	-60	12	-19	-9	-10	0	0	0	0	5	4	-2	0	2	0	0	0	0	3	23	-8	4	-18	-7	9	-42	-7	3	4

	SUBvol^{m}	SUBvol^{m} Pillar 1	SUBvol^{m} Pillar 2	TGM^{n} incl. SUB	TGM^{n} excl. SUB	Cereals	Maize	Fodder crops	Others^{p}	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland^{q}	Conv. of arable land^{r}	Intensive grassland	Extensive grassland	Abandoned UAA^{s}	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)^{u}	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)^{u}	GHG^{w} emissions	Potential AEM area^{x}
	%	%	%	%	%	pp^{o}	pp^{o}	pp^{o}	pp^{o}	pp^{o}	pp^{o}	pp^{o}	pp^{o}	pp^{o}	pp^{o}	pp^{o}	pp^{o}	pp^{o}	pp^{o}	%^{t}	%^{t}	%^{t}	%	%	%	%	%^{v}	%^{v}	%	pp^{o}
PF	-25	-23	4	-10	-2	-4	-1	-7	0	0	4	4	-4	0	17	-13	0	0	0	5	23	-8	46	-3	1	8	-10	-67	-60	2
FDS	-44	-54	9	-15	-4	-14	0	0	0	0	10	4	-1	0	2	-1	0	0	0	2	13	-7	-1	-16	-2	8	-36	3	15	0
FRsk	-42	-69	33	-14	-9	1	-10	0	0	0	3	3	-5	0	3	2	0	0	0	6	13	-9	0	-17	-16	7	-35	-42	-41	-4
FR	-42	-69	33	-14	-9	1	-10	0	0	0	3	3	-5	0	3	2	0	0	0	6	13	-9	0	-17	-16	7	-35	-42	-41	-4
EM	-21	-37	40	-15	-13	9	-19	-1	0	0	0	4	-7	0	2	5	0	0	0	9	13	-18	0	-21	-21	9	-40	-65	-65	-6
OG	-20	-29	32	-18	-18	4	-17	-1	0	0	2	5	-8	0	-4	12	0	0	0	6	13	-20	-7	-26	-23	7	-44	-53	-48	-10
RW	-41	-43	2	-10	2	-6	0	0	0	0	11	1	0	-6	2	-8	0	0	0	3	13	-4	0	-14	2	7	-29	16	28	0
VS	-70	-101	1	-20	-5	1	0	-2	0	0	8	3	0	-10	-5	-6	0	0	0	4	13	6	-5	-6	1	2	-12	32	36	6
TUT	-72	-104	3	-27	-11	-4	0	-2	0	0	7	4	0	-5	0	-4	0	0	0	3	-60	0	0	-9	0	2	-23	24	30	3
KN	-31	-33	10	-17	-13	-12	-1	0	0	0	4	4	-2	2	-1	5	0	0	0	6	13	-12	7	-13	-1	8	-32	-34	-19	-3
LOE	-53	-102	39	-18	-8	1	-7	-3	0	0	1	2	-2	4	2	3	0	0	0	7	13	-14	5	-20	-18	7	-47	-72	-69	-5
WT	-56	-92	26	-20	-10	-9	0	0	0	0	1	2	0	4	2	3	0	0	0	4	13	-13	0	-11	-1	6	-34	-32	-20	4
RT	-52	-71	14	-24	-16	-11	0	-3	0	0	7	3	-3	0	0	3	0	0	0	7	13	-9	-1	-14	-2	7	-41	-4	8	1
TUE	-31	-25	-13	-17	-8	-2	-1	0	0	0	3	5	0	-5	0	-6	0	0	0	1	14	-3	-30	-18	-2	0	-26	-31	-13	-10
BL	-62	-97	16	-16	8	8	0	0	0	0	5	3	0	-15	0	-15	0	0	0	1	23	10	-3	7	12	2	9	36	39	6
ULsk	-23	-13	-22	-15	-12	-26	-1	-2	0	0	7	2	-4	13	1	17	0	0	-3	-13	13	-26	-6	-22	7	4	-48	-30	-1	-9
UL	-23	-13	-22	-15	-12	-26	-1	-2	0	0	7	2	-4	13	1	17	0	0	-3	-13	13	-26	-6	-22	7	4	-48	-30	-1	-9
BC	-23	-23	12	-12	-10	-27	-1	-7	0	0	5	2	-4	24	4	24	0	0	-2	-9	13	-33	14	-30	-7	1	-66	-66	-40	-9
FN	-36	-53	26	-14	-12	-10	-4	-2	0	0	5	2	-6	4	0	9	0	0	0	6	13	-13	3	-16	-9	8	-38	-52	-43	0
RV	-80	-193	40	-22	-16	-10	-2	-5	0	0	0	1	-2	14	4	12	0	0	-4	-14	14	-17	3	-10	-2	-1	-27	-89	-80	-1
SIG	-34	-32	-2	-8	-2	-11	0	-3	0	0	7	3	-2	2	1	3	0	0	0	3	13	-9	-3	-15	4	6	-35	-15	3	-5

m: Subsidy. n: Total gross margin. o: Percent share of utilized agricultural area/percentage points of utilized agricultural area compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare. t: u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. vu: Percentage points difference from reference year. wv: Green house gas. xw: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. n.c.: not calculated.

Table 5.1-23: Development of potential AEM area in NUTS3 regions in the scenario Mandatory AEM (results from Section 3.5).

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	pp	pp	pp	pp	pp	pp	pp
S	48	37	-1	4	0	5	0	66	59	-2	4	0	6	0
BB	48	44	0	0	0	4	0	20	87	0	0	0	5	0
ES	32	33	0	-1	-1	2	0	51	1	0	-1	-1	1	0
GP	37	25	0	6	6	0	0	29	18	0	6	6	1	0
LB	-19	39	-11	21	21	-11	0	10	68	-11	22	22	-10	0
WN	42	28	0	7	7	0	0	22	8	0	7	7	1	0
HNsk	-21	43	-8	11	11	-2	0	-52	89	-8	12	12	-1	0
HN	-21	43	-8	11	11	-2	0	-52	89	-8	12	12	-1	0
KUEN	57	38	0	11	11	-3	0	50	31	0	11	11	-4	0
SHA	50	30	0	15	15	-10	0	45	26	0	15	15	-10	0
TBB	65	46	-1	12	12	-3	0	31	14	-1	11	11	-3	0
HDH	54	31	0	17	17	-11	0	50	91	0	17	17	-11	0
AA	47	21	0	19	19	-14	0	28	2	0	20	20	-13	0
BAD	48	42	1	-1	-1	7	0	34	28	1	-1	-1	7	0
KAsk	-35	60	-6	-8	-8	8	0	-14	80	-6	-8	-8	8	0
KA	-35	60	-6	-8	-8	8	0	-14	80	-6	-8	-8	8	0
RA	48	42	1	-1	-1	7	0	34	28	1	-1	-1	7	0
HDsk	-15	53	-12	12	12	3	0	12	78	-13	12	12	3	0
MAsk	-15	53	-12	12	12	3	0	12	78	-13	12	12	3	0
MOS	54	39	-2	13	13	-10	0	18	4	-2	13	13	-10	0
HD	-15	53	-12	12	12	3	0	12	78	-13	12	12	3	0
PFsk	64	40	18	-7	-7	19	0	83	55	18	-7	-7	19	0
CW	29	30	0	-3	-3	5	0	8	57	0	-2	-2	5	-1
PF	64	40	18	-7	-7	19	0	83	55	18	-7	-7	19	0
FDS	30	31	0	-2	-2	5	-1	17	67	0	-2	-2	5	-1
FRsk	33	27	0	1	1	6	0	14	7	-1	1	1	7	0
FR	33	27	0	1	1	6	0	14	7	-1	1	1	7	0
EM	43	27	0	4	4	10	0	39	23	0	3	3	9	0

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
OG	49	29	-7	10	10	5	0	43	25	-6	11	11	5	0
RW	32	33	0	-1	-1	0	0	29	30	0	-1	-1	0	1
VS	24	18	-5	5	5	0	0	15	9	-5	5	5	1	0
TUT	21	16	-1	5	5	-3	0	13	46	-1	5	5	-3	0
KN	51	33	-3	9	9	2	0	19	2	-4	9	9	3	0
LOE	29	16	10	1	1	1	0	22	10	10	1	1	1	0
WT	-11	22	-1	7	7	-3	0	2	34	0	7	7	-2	0
RT	32	30	0	1	1	0	0	19	63	0	1	1	0	0
TUE	-10	37	-6	10	10	5	0	11	-3	-5	9	9	5	0
BL	16	15	0	0	0	3	0	25	0	0	-1	-1	2	0
ULsk	59	37	0	16	16	-9	0	33	11	-1	17	17	-10	0
UL	59	37	0	16	16	-9	0	33	11	-1	17	17	-10	0
BC	73	29	0	28	28	-12	0	58	14	0	28	28	-12	0
FN	38	22	-1	8	8	0	0	17	1	-1	8	8	0	0
RV	26	8	11	8	8	-8	0	22	2	11	9	9	-8	0
SIG	-19	36	0	4	4	1	0	-52	4	0	4	4	1	0

%UAA: Percentage share of utilized agricultural area. pp: percentage points. NA-2: Crop rotation with four crop groups. NB-1: Cattle density is between 0.3 and 2.0 LU per hectares. NB-2: Cattle density is between 0.3 and 1.4 LU per hectares. NC-4: Regional typical pasture. NE-2: Greening of arable area in autumn. NE-3: Greening of set-aside area.

Table 5.1-24: Development of crop production area in NUTS3 regions in the scenario Mandatory AEM (results from Section 3.5).

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
S	-3	0	0	0	-2	3	0	-2	0	-1	0	0	0	0	0	0	-4	1	2	-23	0	0	0	-4	0	0	5	0
BB	-19	0	-1	2	0	4	0	0	0	0	0	0	0	0	8	1	-1	2	3	-39	0	0	0	-3	0	1	2	0
ES	-6	-1	0	1	0	2	0	-1	0	0	0	0	0	0	2	0	-2	1	3	-23	0	0	0	0	0	3	-3	0
GP	-14	-1	-1	-1	12	1	0	0	0	0	0	0	0	0	0	0	-2	0	1	-24	0	0	0	0	3	2	1	0
LB	-17	8	0	2	-14	1	0	-1	0	0	0	0	0	0	1	2	-1	1	3	-47	0	0	0	-4	12	-6	21	0
WN	-12	-1	0	1	3	5	0	-1	0	0	0	0	0	0	0	0	-2	0	2	-21	0	0	0	-4	3	8	-1	0
HNsk	-17	0	0	1	-4	1	0	0	0	2	0	0	0	0	3	2	0	1	4	-31	0	0	0	-2	5	-4	12	0
HN	-17	0	0	1	-4	1	0	0	0	2	0	0	0	0	3	2	0	1	4	-31	0	0	0	-2	5	-4	12	0
KUEN	-22	-1	0	-3	11	2	0	-2	0	0	0	0	0	0	3	0	-3	0	4	-47	0	0	0	0	9	1	8	0
SHA	-14	-1	-1	-12	9	5	0	-1	0	2	0	0	0	0	1	0	0	0	2	-49	0	0	0	0	11	1	10	0
TBB	-25	0	0	4	-15	6	0	0	0	2	0	0	0	0	13	1	-3	-1	6	-62	0	0	0	-2	10	0	12	0
HDH	-38	0	-1	-4	16	4	0	0	0	1	0	0	0	0	2	0	-1	0	1	-51	0	0	0	-6	13	1	20	0
AA	-22	1	0	0	-10	6	0	0	0	0	0	0	0	0	1	0	0	0	2	-48	0	0	0	-4	16	1	19	0
BAD	-8	1	-2	0	8	5	0	-16	0	1	0	0	0	0	0	1	0	0	8	-8	0	0	0	-3	0	2	1	0
KAsk	-8	0	-2	1	-3	2	0	-4	0	0	0	0	0	0	2	1	-1	1	7	-25	0	0	0	-3	0	-3	6	0
KA	-8	0	-2	1	-3	2	0	-4	0	0	0	0	0	0	2	1	-1	1	7	-25	0	0	0	-3	0	-3	6	0
RA	-8	1	-2	0	8	5	0	-16	0	1	0	0	0	0	0	1	0	0	8	-8	0	0	0	-3	0	2	1	0
HDsk	-12	0	0	1	-4	2	0	-2	0	0	0	0	0	0	1	1	0	1	6	-31	0	0	0	-2	5	-4	11	0
MAsk	-12	0	0	1	-4	2	0	-2	0	0	0	0	0	0	1	1	0	1	6	-31	0	0	0	-2	5	-4	11	0
MOS	-21	0	0	3	-9	4	0	-1	0	0	0	0	0	0	8	0	-2	0	7	-56	0	0	0	0	11	-1	12	0
HD	-12	0	0	1	-4	2	0	-2	0	0	0	0	0	0	1	1	0	1	6	-31	0	0	0	-2	5	-4	11	0
PFsk	-5	0	0	-1	-3	5	0	-1	0	0	0	0	0	0	3	1	-7	1	4	-27	0	0	0	-4	0	17	-13	0
CW	-11	0	-1	-2	-4	8	0	0	0	1	0	0	0	0	3	0	0	1	4	-29	0	0	0	-2	0	2	0	0
PF	-5	0	0	-1	-3	5	0	-1	0	0	0	0	0	0	3	1	-7	1	4	-27	0	0	0	-4	0	17	-13	0

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
FDS	-16	-1	-1	1	-6	7	0	0	0	0	0	0	0	0	9	0	0	0	4	-34	0	0	0	-1	0	2	-1	0
FRsk	-1	0	0	0	0	1	0	-10	0	0	0	0	0	0	0	1	0	0	3	-5	0	0	0	-5	0	3	2	0
FR	-1	0	0	0	0	1	0	-10	0	0	0	0	0	0	0	1	0	0	3	-5	0	0	0	-5	0	3	2	0
EM	-2	3	2	1	4	2	0	-19	0	0	0	0	0	0	0	0	1	-2	4	2	0	0	0	-7	0	2	5	0
OG	-9	2	1	1	6	4	0	-17	0	0	0	0	0	0	0	1	0	0	5	-2	0	0	0	-8	0	-4	12	0
RW	-27	0	0	-4	18	7	0	0	0	0	0	0	0	0	10	0	-1	0	1	-33	0	0	0	0	-6	2	-8	0
VS	-3	0	0	3	-1	4	0	0	0	1	0	0	0	0	8	0	-2	0	3	-17	0	0	0	0	-10	-5	-6	0
TUT	-16	0	0	8	0	4	0	0	0	0	0	0	0	0	7	0	-2	1	4	-22	0	0	0	0	-5	0	-4	0
KN	-10	0	-1	1	-5	3	0	-1	0	0	0	0	0	0	4	0	-2	2	4	-32	0	0	0	-2	2	-1	5	0
LOE	-5	1	0	2	1	1	0	-7	0	0	0	0	0	0	0	0	-3	0	2	-8	0	0	0	-2	4	2	3	0
WT	-6	1	0	2	-8	3	0	0	0	0	0	0	0	0	1	0	0	1	2	-23	0	0	0	0	4	2	3	0
RT	-11	0	0	1	-6	5	0	0	0	2	0	0	0	0	5	0	-4	1	3	-28	0	0	0	-3	0	0	3	0
TUE	3	0	0	-2	-2	0	0	-1	0	2	0	0	0	0	2	-1	0	1	5	-37	0	0	0	0	-5	0	-6	0
BL	0	0	0	2	0	6	0	0	0	0	0	0	0	0	4	0	-1	1	3	-15	0	0	0	0	-15	0	-15	0
ULsk	-26	0	0	4	-9	7	0	-1	0	1	0	0	0	0	7	0	-1	0	2	-62	0	0	0	-4	13	1	17	0
UL	-26	0	0	4	-9	7	0	-1	0	1	0	0	0	0	7	0	-1	0	2	-62	0	0	0	-4	13	1	17	0
BC	-38	0	1	-1	8	4	0	-1	0	0	0	0	0	0	4	0	-4	-4	2	-56	0	0	0	-4	24	4	24	0
FN	-13	1	0	4	-2	1	0	-4	0	0	0	0	0	0	1	3	-2	0	2	-20	0	0	0	-6	4	0	9	0
RV	-7	0	0	-3	1	0	0	-2	0	0	0	0	0	0	0	0	-2	-3	1	-18	0	0	0	-2	14	4	12	0
SIG	-15	0	0	3	-5	5	0	0	0	2	0	0	0	0	6	0	-4	1	3	-41	0	0	0	-2	2	1	3	0

pp: percentage points.

Table 5.1-25: Development of economic, production and environmental indicator values in NUTS3 regions in the scenario INT (results from Section 3.6).

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	% [t]	% [t]	% [t]	%	%	%	%	%[v]	%[v]	%	pp[o]
S	-115	-114	-54	-23	-12	-35	35	-4	0	0	0	2	-2	0	2	0	0	0	0	-1	23	0	-50	-20	-5	5	-29	69	82	-4
BB	-95	-85	-65	-48	-32	-56	50	-2	0	0	3	3	-3	0	1	2	0	0	0	3	11	-5	-21	-22	12	6	-36	131	163	-6
ES	-118	-148	-11	-40	-19	-29	35	-4	0	0	0	3	5	0	3	-8	0	0	0	2	14	12	-4	-12	6	4	-21	120	135	5
GP	-127	-194	11	-27	-5	-9	14	0	0	0	1	1	6	-2	2	-10	0	0	0	1	13	6	-3	-17	-5	-1	-29	62	69	9
LB	-77	-60	-107	-34	-26	-58	52	-1	0	0	2	3	-2	0	5	-4	0	0	0	2	12	-3	18	-11	8	4	-19	86	103	-2
WN	-114	-171	20	-23	-8	-3	-1	0	0	0	1	2	-2	0	8	-6	0	0	0	5	13	-9	0	-10	-3	8	-28	-26	-18	5
HNsk	-79	-58	-155	-34	-28	-56	48	-1	0	0	3	4	-1	0	4	-3	0	0	0	3	11	-4	-42	-18	1	5	-25	87	103	-8
HN	-79	-58	-155	-34	-28	-56	48	-1	0	0	3	4	-1	0	4	-3	0	0	0	3	11	-4	-42	-18	1	5	-25	87	103	-8
KUEN	-90	-79	-73	-16	-3	-33	33	-3	0	0	2	4	2	0	2	-4	0	0	0	4	13	-2	-5	-17	14	6	-37	69	95	-3
SHA	-96	-109	-12	-13	2	-8	-1	0	0	0	4	2	0	-2	1	-3	0	5	0	3	13	-11	-3	-10	8	5	-34	-15	4	2
TBB	-74	-48	-161	-34	-20	-56	45	-3	0	0	7	6	-1	0	1	0	0	0	0	3	13	-4	38	-14	31	6	-23	103	139	-6
HDH	-88	-100	-6	-28	-10	-9	0	0	0	0	4	1	-3	0	1	3	0	0	0	4	13	-7	-1	-18	-2	4	-39	-15	0	-2
AA	-107	-147	8	-27	-11	-12	0	1	0	0	4	2	-4	0	1	1	0	5	0	4	13	-14	-1	-8	6	3	-29	-20	-5	3
BAD	-74	-76	-18	-40	-30	-12	0	-2	0	0	2	8	-3	0	2	1	0	0	0	6	20	-8	-4	-24	-13	10	-35	-5	6	-15
KAsk	-71	-54	-109	-65	-62	-54	47	-2	0	0	0	7	-2	0	0	2	0	0	0	3	11	0	3	-14	9	6	-20	78	102	-12
KA	-71	-54	-109	-65	-62	-54	47	-2	0	0	0	7	-2	0	0	2	0	0	0	3	11	0	3	-14	9	6	-20	78	102	-12
RA	-74	-76	-18	-40	-30	-12	0	-2	0	0	2	8	-3	0	2	1	0	0	0	6	20	-8	-4	-24	-13	10	-35	-5	6	-15
HDsk	-73	-57	-101	-40	-31	-53	46	-1	0	0	1	6	-1	0	2	-2	0	0	0	2	11	-5	-50	-17	3	4	-27	72	94	-9
MAsk	-73	-57	-101	-40	-31	-53	46	-1	0	0	1	6	-1	0	2	-2	0	0	0	2	11	-5	-50	-17	3	4	-27	72	94	-9
MOS	-86	-68	-101	-34	-13	-51	44	-4	0	0	5	7	2	0	2	-4	0	0	0	3	13	-2	42	-17	23	3	-32	130	163	-6
HD	-73	-57	-101	-40	-31	-53	46	-1	0	0	1	6	-1	0	2	-2	0	0	0	2	11	-5	-50	-17	3	4	-27	72	94	-9
PFsk	-82	-95	4	-32	-11	-8	-1	-5	0	0	5	4	-6	0	12	-6	0	0	0	7	23	-12	28	-3	3	10	-11	-67	-58	2
CW	-116	-161	5	-39	-12	-17	0	0	0	0	3	4	-4	0	2	0	0	9	0	2	23	-16	3	-10	5	9	-36	-18	-3	2

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	%[t]	%[t]	%[t]	%	%	%	%	%[v]	%[v]	%	pp[o]
PF	-82	-95	4	-32	-11	-8	-1	-5	0	0	5	4	-6	0	12	-6	0	0	0	7	23	-12	28	-3	3	10	-11	-67	-58	2
FDS	-114	-148	-6	-33	-3	-25	20	0	0	0	5	4	3	0	2	-5	0	0	0	-1	13	-1	-2	-13	9	6	-26	107	117	1
FRsk	-113	-170	26	-23	-8	-8	0	0	0	0	2	3	-5	0	3	2	0	0	0	6	13	-7	0	-17	-12	7	-35	-13	-8	-4
FR	-113	-170	26	-23	-8	-8	0	0	0	0	2	3	-5	0	3	2	0	0	0	6	13	-7	0	-17	-12	7	-35	-13	-8	-4
EM	-84	-118	30	-20	-9	-1	-7	0	0	0	0	4	-4	0	1	3	0	0	0	7	13	-10	-1	-11	-9	8	-25	-29	-27	-2
OG	-83	-106	16	-28	-18	-16	7	-2	0	0	2	5	-4	0	4	1	0	0	0	5	12	-8	-4	-15	-10	10	-29	9	16	-5
RW	-106	-130	-6	-24	6	-8	11	0	0	0	7	0	3	-6	2	-11	0	0	0	2	13	3	-1	-14	5	5	-27	73	80	0
VS	-143	-223	-3	-36	-5	0	2	-2	0	0	6	3	0	-9	1	-12	0	1	0	5	13	4	2	-2	6	3	-3	39	44	6
TUT	-148	-232	-4	-39	0	0	0	-2	0	0	5	4	0	-12	1	-13	0	5	0	2	20	2	0	2	9	3	-7	27	32	5
KN	-101	-112	-20	-32	-15	-36	31	-2	0	0	4	4	2	0	4	-5	0	0	0	4	13	-2	33	-8	15	5	-20	75	98	-1
LOE	-126	-221	34	-35	-14	-11	18	-5	0	0	1	2	5	0	-9	3	0	0	0	6	11	0	1	-5	-4	6	-19	39	38	4
WT	-122	-203	26	-34	-10	-7	0	1	0	0	2	2	0	2	2	2	0	0	0	5	13	-12	-2	-7	2	6	-27	-26	-16	6
RT	-118	-175	14	-37	-12	-7	0	-3	0	0	4	3	-3	0	0	2	0	0	0	6	13	-9	0	-12	0	8	-36	-9	2	4
TUE	-102	-99	-54	-40	-8	-27	36	0	0	0	0	5	3	-10	6	-20	0	0	0	-5	14	9	2	-20	9	-2	-27	109	131	-9
BL	-145	-224	0	-38	18	5	8	0	0	0	4	2	0	-29	0	-30	0	12	0	-1	23	11	-2	22	28	-1	29	113	114	7
ULsk	-81	-80	-29	-21	-6	-11	-1	0	0	0	6	2	-2	0	1	1	0	0	0	4	13	-8	-7	-13	8	6	-29	-10	10	0
UL	-81	-80	-29	-21	-6	-11	-1	0	0	0	6	2	-2	0	1	1	0	0	0	4	13	-8	-7	-13	8	6	-29	-10	10	0
BC	-84	-97	-1	-13	-1	-7	-1	-1	0	0	4	2	-2	0	5	-3	0	0	0	6	13	-8	4	-8	5	7	-26	-27	-12	2
FN	-101	-144	23	-18	-10	-7	-2	-1	0	0	5	2	-4	0	1	3	0	0	0	6	13	-7	-6	-9	-3	8	-24	-35	-28	3
RV	-166	-366	32	-24	-8	-3	6	0	0	0	1	1	6	0	-8	3	0	0	0	5	14	0	-1	1	6	4	-5	15	19	6
SIG	-99	-111	-16	-18	0	-16	14	-2	0	0	4	3	2	0	1	-3	0	0	0	4	13	-2	-3	-14	8	6	-32	45	59	-4

m: Subsidy. n: Total gross margin. o: Percent share of utilized agricultural area/percentage points of utilized agricultural area compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare. t: u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. vu: Percentage points difference from reference year. wv: Green house gas. xw: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. n.c.: not calculated.

Table 5.1-26: Development of potential AEM area in NUTS3 regions in the scenario INT (results from Section 3.6).

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	pp	pp	pp	pp	pp	pp	pp
S	-28	0	1	-1	0	-28	0	-11	22	1	-1	0	-28	0
BB	-9	21	12	0	0	-42	0	-37	63	12	0	0	-41	0
ES	-37	1	1	-7	-7	-24	0	-18	-32	1	-6	-6	-24	0
GP	1	15	0	-5	-5	-5	0	-7	8	0	-5	-5	-5	0
LB	-122	0	3	-3	-3	-40	0	-92	29	3	-3	-3	-40	0
WN	27	20	0	2	2	3	0	7	0	0	2	2	4	0
HNsk	-122	0	2	-3	-3	-41	0	-154	46	3	-3	-3	-41	0
HN	-122	0	2	-3	-3	-41	0	-154	46	3	-3	-3	-41	0
KUEN	-24	3	1	-1	-1	-25	0	-31	-5	1	-1	-1	-25	0
SHA	22	23	0	1	1	-2	0	17	18	0	1	1	-2	0
TBB	-13	24	0	0	0	-37	0	-47	-8	0	0	0	-37	0
HDH	31	26	0	0	0	4	0	27	87	0	0	0	5	0
AA	5	3	0	1	1	-1	0	-14	-16	0	1	1	-1	0
BAD	-5	3	1	-1	-1	-8	0	-19	-10	1	-1	-1	-8	0
KAsk	-120	2	0	0	0	-38	0	-99	22	1	0	0	-38	0
KA	-120	2	0	0	0	-38	0	-99	22	1	0	0	-38	0
RA	-5	3	1	-1	-1	-8	0	-19	-10	1	-1	-1	-8	0
HDsk	-103	15	2	-1	-1	-35	0	-76	40	1	-1	-1	-35	0
MAsk	-103	15	2	-1	-1	-35	0	-76	40	1	-1	-1	-35	0
MOS	-21	23	1	-3	-3	-39	0	-56	-12	1	-3	-3	-39	0
HD	-103	15	2	-1	-1	-35	0	-76	40	1	-1	-1	-35	0
PFsk	37	8	13	0	0	15	0	56	24	13	0	0	15	0
CW	-7	2	0	-3	-3	-4	0	-28	29	0	-3	-3	-4	-1
PF	37	8	13	0	0	15	0	56	24	13	0	0	15	0
FDS	-22	2	0	-6	-6	-11	-1	-35	38	0	-6	-6	-11	-1
FRsk	14	16	0	1	1	-2	0	-6	-4	-1	1	1	-2	0
FR	14	16	0	1	1	-2	0	-6	-4	-1	1	1	-2	0
EM	8	4	-1	2	2	2	0	4	0	-1	1	1	2	0

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	pp	pp	pp	pp	pp	pp	pp
OG	-8	4	1	-1	-1	-12	0	-14	-1	2	-1	-1	-12	0
RW	12	27	0	-4	-4	-6	-1	9	24	0	-4	-4	-7	0
VS	0	3	0	0	0	-3	0	-8	-5	0	0	0	-2	0
TUT	-1	7	1	-4	-4	-1	0	-9	38	1	-3	-3	-1	0
KN	-22	1	1	-1	-1	-21	0	-53	-31	0	-1	-1	-20	0
LOE	-7	0	-1	1	1	-9	0	-14	-6	-1	1	1	-8	0
WT	-33	3	-1	5	5	-1	0	-20	14	0	5	5	-1	0
RT	17	15	0	1	1	1	0	4	48	0	1	1	1	0
TUE	-72	26	0	-4	-4	-23	0	-50	-14	0	-4	-4	-23	0
BL	-32	1	0	-15	-15	-1	-1	-23	-15	0	-15	-15	-2	-1
ULsk	31	26	0	0	0	4	0	5	0	0	1	1	4	0
UL	31	26	0	0	0	4	0	5	0	0	1	1	4	0
BC	26	15	0	1	1	8	0	10	0	0	2	2	8	0
FN	15	7	0	2	2	3	0	-6	-14	0	3	3	3	0
RV	2	5	-1	-1	-1	0	0	-2	-1	-1	0	0	-1	0
SIG	-38	38	0	-2	-2	-7	0	-71	5	1	-2	-2	-7	0

%UAA: Percentage share of utilized agricultural area. pp: percentage points. NA-2: Crop rotation with four crop groups. NB-1: Cattle density is between 0.3 and 2.0 LU per hectares. NB-2: Cattle density is between 0.3 and 1.4 LU per hectares. NC-4: Regional typical pasture. NE-2: Greening of arable area in autumn. NE-3: Greening of set-aside area.

Table 5.1-27: Development of crop production area in NUTS3 regions in the scenario INT (results from Section 3.6).

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
S	-22	0	0	-1	-15	3	0	-5	40	-1	0	0	0	0	0	0	-5	1	2	-39	0	0	0	-2	0	2	0	0
BB	-50	-1	-1	1	-7	3	0	-1	50	-1	0	0	0	0	3	1	-3	1	3	-75	0	0	0	-3	0	1	2	0
ES	-20	-3	-1	0	-6	0	0	-2	37	0	0	0	0	0	1	0	-4	0	3	-41	0	0	0	5	0	3	-8	0
GP	-14	-2	-1	-1	7	1	0	0	14	0	0	0	0	0	0	0	-1	1	1	-29	0	0	0	6	-2	2	-10	0
LB	-42	-2	0	0	-14	0	0	-4	56	0	0	0	0	0	0	2	-2	1	3	-50	0	0	0	-2	0	5	-4	0
WN	-9	-1	0	1	1	5	0	-1	0	0	0	0	0	0	1	0	-1	1	2	-19	0	0	0	-2	0	8	-6	0
HNsk	-42	-1	-1	0	-15	1	0	-4	52	1	0	0	0	0	1	2	-1	0	4	-44	0	0	0	-1	0	4	-3	0
HN	-42	-1	-1	0	-15	1	0	-4	52	1	0	0	0	0	1	2	-1	0	4	-44	0	0	0	-1	0	4	-3	0
KUEN	-34	-2	0	-3	4	2	0	-3	36	0	0	0	0	0	1	0	-4	0	4	-68	0	0	0	2	0	2	-4	0
SHA	-12	-1	-1	-6	8	4	0	-1	0	1	0	0	0	0	3	0	0	1	2	-41	0	0	0	0	-2	1	-4	0
TBB	-39	-1	-1	4	-21	2	0	0	45	1	0	0	0	0	5	1	-3	1	6	-95	0	0	0	-1	0	1	0	0
HDH	-25	0	-1	-1	15	4	0	0	0	1	0	0	0	0	3	0	0	1	1	-36	0	0	0	-3	0	1	3	0
AA	-10	0	0	3	-10	5	0	0	0	0	0	0	0	0	3	0	0	1	2	-35	0	0	0	-4	0	1	1	0
BAD	-11	0	-4	0	0	3	0	-12	12	1	0	0	0	0	0	1	-1	1	8	-22	0	0	0	-3	0	2	1	0
KAsk	-28	-2	-10	-1	-16	2	0	-9	56	-1	0	0	0	0	0	1	-3	1	7	-53	0	0	0	-2	0	0	2	0
KA	-28	-2	-10	-1	-16	2	0	-9	56	-1	0	0	0	0	0	1	-3	1	7	-53	0	0	0	-2	0	0	2	0
RA	-11	0	-4	0	0	3	0	-12	12	1	0	0	0	0	0	1	-1	1	8	-22	0	0	0	-3	0	2	1	0
HDsk	-36	-2	-2	-1	-13	2	0	-7	53	0	0	0	0	0	1	1	-1	0	6	-51	0	0	0	-1	0	2	-2	0
MAsk	-36	-2	-2	-1	-13	2	0	-7	53	0	0	0	0	0	1	1	-1	0	6	-51	0	0	0	-1	0	2	-2	0
MOS	-43	-1	-1	2	-10	3	0	-2	45	0	0	0	0	0	5	0	-4	0	7	-85	0	0	0	2	0	2	-4	0
HD	-36	-2	-2	-1	-13	2	0	-7	53	0	0	0	0	0	1	1	-1	0	6	-51	0	0	0	-1	0	2	-2	0
PFsk	-2	1	1	3	-15	4	0	-1	0	0	0	0	0	0	4	1	-6	1	4	-31	0	0	0	-6	0	12	-6	0
CW	-6	0	-1	0	-17	6	0	0	0	0	0	0	0	0	2	0	0	1	4	-38	0	0	0	-4	0	2	0	0
PF	-2	1	1	3	-15	4	0	-1	0	0	0	0	0	0	4	1	-6	1	4	-31	0	0	0	-6	0	12	-6	0

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
FDS	-14	-1	-1	1	-17	6	0	0	20	0	0	0	0	0	4	0	0	0	4	-49	0	0	0	3	0	2	-5	0
FRsk	-6	0	0	0	-2	1	0	-8	7	0	0	0	0	0	0	1	0	0	3	-13	0	0	0	-5	0	3	2	0
FR	-6	0	0	0	-2	1	0	-8	7	0	0	0	0	0	0	1	0	0	3	-13	0	0	0	-5	0	3	2	0
EM	-4	0	0	0	1	2	0	-7	0	0	0	0	0	0	0	0	0	0	4	-6	0	0	0	-4	0	1	3	0
OG	-17	-1	0	0	3	1	0	-16	23	0	0	0	0	0	0	1	0	0	5	-10	0	0	0	-4	0	4	1	0
RW	-27	0	0	-4	17	6	0	0	11	0	0	0	0	0	6	0	-1	0	0	-39	0	0	0	3	-6	2	-11	0
VS	0	0	0	4	-7	4	0	0	2	1	0	0	0	0	6	0	-2	0	3	-20	0	0	0	0	-9	1	-12	0
TUT	-5	0	0	4	-2	4	0	0	0	0	0	0	0	0	5	0	-2	1	4	-21	0	0	0	0	-12	1	-13	0
KN	-23	0	0	0	-13	2	0	-2	33	0	0	0	0	0	4	0	-4	2	4	-55	0	0	0	2	0	4	-5	0
LOE	-11	-1	0	1	-1	1	0	-9	27	0	0	0	0	0	0	0	-5	0	2	-5	0	0	0	5	0	-9	3	0
WT	-4	0	0	3	-11	5	0	0	0	0	0	0	0	0	1	1	0	1	2	-22	0	0	0	0	2	2	2	0
RT	-9	0	0	2	-5	5	0	0	0	1	0	0	0	0	3	0	-3	0	3	-27	0	0	0	-3	0	0	2	0
TUE	-14	-1	0	-4	-4	-3	0	-2	38	2	0	0	0	0	-1	-1	-1	1	5	-65	0	0	0	3	-10	6	-20	0
BL	0	0	0	2	-5	9	0	0	8	0	0	0	0	0	4	0	-1	1	2	-19	0	0	0	0	-29	0	-30	0
ULsk	-15	0	0	8	-6	4	0	-1	0	1	0	0	0	0	6	0	-1	1	2	-48	0	0	0	-2	0	1	1	0
UL	-15	0	0	8	-6	4	0	-1	0	1	0	0	0	0	6	0	-1	1	2	-48	0	0	0	-2	0	1	1	0
BC	-16	0	1	3	2	4	0	-1	0	0	0	0	0	0	3	0	-2	1	2	-36	0	0	0	-2	0	5	-3	0
FN	-5	0	0	2	-5	1	0	-2	0	0	0	0	0	0	1	3	-2	1	2	-16	0	0	0	-4	0	1	3	0
RV	-2	0	0	-1	0	1	0	-1	7	0	0	0	0	0	1	0	0	0	1	-10	0	0	0	6	0	-8	3	0
SIG	-18	0	0	2	-5	5	0	0	14	1	0	0	0	0	4	0	-5	2	3	-49	0	0	0	2	0	1	-3	0

pp: percentage points.

Table 5.1-28: Development of economic, production and environmental indicator values in NUTS3 regions in the scenario EXT (results from Section 3.6).

	SUBvol[m]	SUBvol[m] Pillar 1	SUBvol[m] Pillar 2	TGM[n] incl. SUB	TGM[n] excl. SUB	Cereals	Maize	Fodder crops	Others[p]	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland[q]	Conv. of arable land[r]	Intensive grassland	Extensive grassland	Abandoned UAA[s]	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)[u]	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)[u]	GHG[w] emissions	Potential AEM area[x]
	%	%	%	%	%	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	pp[o]	%[t]	%[t]	%[t]	%	%	%	%	%[v]	%[v]	%	pp[o]
S	-133	-136	-57	-23	-10	-16	1	-5	0	0	0	2	-2	0	7	-5	0	17	-13	-13	16	-23	-35	-22	-4	-10	-31	1	19	-21
BB	-89	-99	1	-39	-23	-25	5	-1	0	0	5	3	-6	1	-3	10	0	7	0	3	6	-23	-6	-33	-8	1	-54	-6	16	-17
ES	-117	-168	25	-36	-14	-14	4	-3	0	0	1	3	0	6	-3	4	0	9	0	0	9	-5	-2	-21	-5	-2	-39	13	27	-7
GP	-132	-219	31	-31	-10	-16	3	-2	0	0	0	1	0	3	-2	4	0	12	0	-4	9	-18	-7	-26	-8	-3	-63	-20	-3	5
LB	-78	-75	-35	-30	-21	-39	9	-1	0	0	2	3	-4	10	-4	17	0	5	-10	-8	7	-31	-18	-26	-6	-3	-39	-12	8	-17
WN	-123	-194	35	-27	-12	-21	2	-2	0	0	1	2	-4	3	2	4	0	9	0	-1	8	-25	-3	-24	-10	4	-60	-25	-10	1
HNsk	-79	-70	-70	-27	-20	-28	4	0	0	0	4	4	-2	5	-5	12	0	8	-7	-6	3	-21	-17	-28	-9	-3	-38	-3	13	-22
HN	-79	-70	-70	-27	-20	-28	4	0	0	0	4	4	-2	5	-5	12	0	8	-7	-6	3	-21	-17	-28	-9	-3	-38	-3	13	-22
KUEN	-87	-93	-7	-15	-3	-25	3	-3	0	0	3	4	0	10	-2	11	0	10	0	-4	6	-24	-10	-27	1	2	-60	-16	11	-15
SHA	-94	-121	23	-16	-1	-22	1	-1	0	0	2	2	0	16	-2	14	0	5	0	-12	8	-24	-4	-17	10	2	-58	-27	0	0
TBB	-66	-59	-40	-34	-22	-35	0	-3	0	0	12	8	-2	10	-1	13	0	6	-1	-8	9	-29	4	-30	5	3	-49	-25	8	-21
HDH	-89	-113	25	-32	-14	-28	4	-2	0	0	2	1	-6	12	0	19	0	3	-4	-10	4	-24	-7	-27	-1	-1	-68	-21	2	-14
AA	-102	-159	41	-33	-19	-28	5	0	0	0	2	2	-4	14	-3	21	0	1	0	-6	10	-27	4	-18	4	-1	-61	-25	-4	0
BAD	-79	-92	21	-45	-35	-11	-20	-2	0	0	4	8	-6	2	-3	10	0	14	0	2	15	-27	-11	-44	-34	4	-64	-40	-30	-39
KAsk	-79	-71	-63	-54	-42	-39	1	-1	0	0	2	7	-4	3	-4	10	0	17	0	2	6	-38	-36	-29	-7	1	-40	-12	9	-35
KA	-79	-71	-63	-54	-42	-39	1	-1	0	0	2	7	-4	3	-4	10	0	17	0	2	6	-38	-36	-29	-7	1	-40	-12	9	-35
RA	-79	-92	21	-45	-35	-11	-20	-2	0	0	4	8	-6	2	-3	10	0	14	0	2	15	-27	-11	-44	-34	4	-64	-40	-30	-39
HDsk	-77	-73	-41	-37	-26	-37	3	-1	0	0	2	6	-2	9	-4	12	0	11	0	-2	7	-35	-50	-15	4	1	-28	-17	4	-20
MAsk	-77	-73	-41	-37	-26	-37	3	-1	0	0	2	6	-2	9	-4	12	0	11	0	-2	7	-35	-50	-15	4	1	-28	-17	4	-20
MOS	-82	-82	-27	-36	-18	-38	8	-3	0	0	6	7	0	13	-2	12	0	9	0	-4	8	-28	8	-32	5	1	-58	15	46	-17
HD	-77	-73	-41	-37	-26	-37	3	-1	0	0	2	6	-2	9	-4	12	0	11	0	-2	7	-35	-50	-15	4	1	-28	-17	4	-20
PFsk	-85	-107	28	-35	-13	-23	16	-9	0	0	2	4	-6	6	6	5	0	0	0	1	15	-13	19	-26	-12	-1	-41	-20	-6	-10
CW	-121	-178	21	-36	-6	-18	2	-2	0	0	2	4	-4	7	1	-3	0	15	0	1	23	-16	1	-31	-14	-2	-61	-3	12	-4

	SUBvol^m	SUBvol^m Pillar 1	SUBvol^m Pillar 2	TGM^n incl. SUB	TGM^n excl. SUB	Cereals	Maize	Fodder crops	Others^p	Root crops	Oil seeds and legumes	Set-aside area	Conv. of grassland^q	Conv. of arable land^r	Intensive grassland	Extensive grassland	Abandoned UAA^s	Intensive crop area	Intensive variant area	Dairy cows	Bulls	Fattening pigs	Nitrogen total	Nitrogen total (weight.)^u	Nitrogen organic	Nitrogen demand	Erosion potential	Erosion pot. (weight.)^u	GHG^w emissions	Potential AEM area^x
	%	%	%	%	%	pp^o	pp^o	pp^o	pp^o	pp^o	pp^o	pp^o	pp^o	pp^o	pp^o	pp^o	pp^o	pp^o	pp^o	%^{t}	%^{t}	%^{t}	%	%	%	%	%^{v}	%^{v}	%	pp^o
PF	-85	-107	28	-35	-13	-23	16	-9	0	0	2	4	-6	6	6	5	0	0	0	1	15	-13	19	-26	-12	-1	-41	-20	-6	-10
FDS	-119	-171	18	-33	-1	-26	0	-1	0	0	8	4	-1	0	1	-2	0	16	0	-1	9	-18	-4	-21	1	5	-55	-10	9	-9
FRsk	-109	-187	60	-26	-12	-8	-14	0	0	0	2	3	-10	7	13	4	0	0	0	-2	4	-20	10	-41	-36	1	-70	-65	-60	-16
FR	-109	-187	60	-26	-12	-8	-14	0	0	0	2	3	-10	7	13	4	0	0	0	-2	4	-20	10	-41	-36	1	-70	-65	-60	-16
EM	-82	-134	70	-26	-16	1	-23	-2	0	0	0	4	-8	6	-5	19	0	4	0	5	9	-29	1	-30	-28	6	-57	-80	-77	-14
OG	-81	-121	58	-28	-19	0	-20	-1	0	0	2	5	-8	2	-6	17	0	4	0	4	7	-24	-12	-30	-26	4	-52	-58	-52	-16
RW	-115	-152	10	-26	6	-14	1	-1	0	0	8	1	1	-6	1	-12	0	16	0	2	11	-13	1	-20	2	-1	-44	16	32	-8
VS	-137	-242	29	-35	-5	-1	1	-2	0	0	7	3	0	-8	-5	-3	0	1	0	3	10	4	-5	-7	0	1	-20	29	35	6
TUT	-147	-253	18	-38	0	-3	1	-3	0	0	6	4	0	-12	1	-12	0	8	0	1	20	0	0	-2	6	2	-18	31	37	4
KN	-103	-130	15	-32	-14	-31	8	-2	0	0	4	4	-2	1	-3	6	0	13	0	1	6	-21	2	-20	0	1	-48	-3	17	-13
LOE	-122	-241	63	-30	-9	-2	-8	-3	0	0	1	2	-2	9	3	6	0	0	0	3	7	-18	-4	-32	-29	2	-65	-86	-82	-11
WT	-124	-225	45	-33	-7	-13	2	-1	0	0	1	2	0	6	-2	7	0	5	0	0	7	-15	-4	-20	-8	-1	-53	-26	-13	1
RT	-120	-195	37	-39	-14	-18	1	-8	0	0	5	4	-6	8	-2	10	0	5	0	3	7	-20	-2	-32	-15	3	-77	-18	-2	-2
TUE	-100	-115	-4	-37	-4	-17	9	-1	0	0	0	5	0	-7	-1	-7	0	10	0	-5	9	-9	-49	-30	-5	-6	-44	7	28	-21
BL	-145	-244	22	-37	19	6	1	0	0	0	5	2	0	-29	0	-29	0	16	0	-1	23	8	-1	18	24	-1	17	54	57	5
ULsk	-81	-93	12	-26	-13	-29	3	-3	0	0	4	2	-4	13	-2	20	0	3	-5	-10	7	-29	-6	-27	4	1	-59	-19	10	-13
UL	-81	-93	12	-26	-13	-29	3	-3	0	0	4	2	-4	13	-2	20	0	3	-5	-10	7	-29	-6	-27	4	1	-59	-19	10	-13
BC	-83	-109	33	-22	-11	-34	12	-7	0	0	3	2	-4	20	3	21	0	0	-10	-13	12	-28	7	-31	-5	-3	-63	-26	1	-11
FN	-104	-162	48	-20	-13	-12	-3	-2	0	0	3	2	-6	1	-6	13	0	6	0	3	7	-13	-19	-22	-14	2	-48	-46	-37	-6
RV	-164	-395	55	-28	-13	-11	1	-3	0	0	0	1	-2	11	8	4	0	0	-7	-15	14	-15	8	-17	-9	-4	-39	-62	-52	-3
SIG	-105	-130	8	-21	-1	-22	3	-5	0	0	2	3	-2	1	0	3	0	15	0	1	7	-22	-5	-19	6	0	-50	-11	12	-15

m: Subsidy. n: Total gross margin. o: Percent share of utilized agricultural area/percentage points of utilized agricultural area compared to the share in reference year. p: Aggregated area of root crops, oil seeds, legumes, set-aside area and special crops. q: Conversion of grassland into arable land. r: Conversion of arable land into grassland. s: Utilized agricultural area not agriculturally used and not entitled for subsidy payments. t: heads per hectare. t: u: Weighted by acreage of intercrops reducing the impact of nitrate leaching and erosion. vu: Percentage points difference from reference year. wv: Green house gas. xw: Area where potentially agri-environmental measures (AEM) can be applied to, but which are not necessarily implied in optimization process and thus not simulated as activity. n.c.: not calculated.

Table 5.1-29: Development of potential AEM area in NUTS3 regions in the scenario EXT (results from Section 3.6).

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	%UAA	pp	pp	pp	pp	pp	pp	pp
S	6	28	6	-6	0	-16	0	23	50	5	-6	0	-16	0
BB	49	42	0	9	9	-9	0	22	85	0	9	9	-9	0
ES	24	29	-5	5	5	-10	0	43	-4	-5	6	6	-10	0
GP	15	17	-4	9	9	-17	0	7	10	-4	10	10	-17	0
LB	-27	38	-6	18	18	-15	0	3	67	-6	18	18	-14	0
WN	19	20	-13	12	12	-12	0	0	0	-13	12	12	-11	0
HNsk	-20	54	-8	12	12	-13	0	-51	100	-8	12	12	-12	0
HN	-20	54	-8	12	12	-13	0	-51	100	-8	12	12	-12	0
KUEN	41	33	-3	14	14	-16	0	34	25	-3	14	14	-16	0
SHA	41	27	-3	18	18	-17	0	36	22	-3	17	17	-18	0
TBB	56	42	-2	13	13	-12	2	23	10	-2	13	13	-12	2
HDH	46	30	-1	16	16	-16	0	42	90	-1	17	17	-16	0
AA	46	24	-3	21	21	-18	0	26	5	-3	21	21	-17	0
BAD	39	31	-4	8	8	-5	0	25	17	-4	8	8	-5	0
KAsk	-50	37	-4	8	8	-16	0	-29	57	-4	8	8	-15	0
KA	-50	37	-4	8	8	-16	0	-29	57	-4	8	8	-15	0
RA	39	31	-4	8	8	-5	0	25	17	-4	8	8	-5	0
HDsk	-38	38	-5	12	12	-12	0	-11	63	-5	12	12	-13	0
MAsk	-38	38	-5	12	12	-12	0	-11	63	-5	12	12	-13	0
MOS	32	34	-3	13	13	-26	0	-3	-1	-3	13	13	-26	0
HD	-38	38	-5	12	12	-12	0	-11	63	-5	12	12	-13	0
PFsk	68	39	7	12	12	-2	0	87	55	7	12	12	-1	0
CW	5	24	-1	-6	-6	-6	0	-17	51	-1	-5	-5	-6	-1
PF	68	39	7	12	12	-2	0	87	55	7	12	12	-1	0
FDS	6	22	0	-3	-3	-8	-1	-8	58	-1	-3	-3	-9	-1
FRsk	33	20	11	2	2	-1	0	14	1	10	2	2	-1	0
FR	33	20	11	2	2	-1	0	14	1	10	2	2	-1	0
EM	52	21	-8	18	18	4	0	48	16	-7	17	17	4	0

	Potential AEM area	Acreage NA-2	Acreage NB-1	Acreage NB-2	Acreage NC-4	Acreage NE-2	Acreage NE-3	Difference AEM area	Difference NA-2	Difference NB-1	Difference NB-2	Difference NC-4	Difference NE-2	Difference NE-3
	%UAA	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**%UAA**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
OG	48	25	-9	15	15	1	0	43	21	-9	15	15	1	0
RW	5	26	-1	-5	-5	-11	1	3	23	-1	-5	-5	-11	1
VS	24	16	-6	8	8	-3	0	15	7	-6	8	8	-2	0
TUT	5	15	0	-3	-3	-4	0	-3	45	0	-2	-2	-4	0
KN	25	27	-5	9	9	-16	0	-6	-5	-6	9	9	-15	0
LOE	32	14	11	4	4	-2	0	25	7	11	5	5	-1	0
WT	-6	29	-5	10	10	-7	0	7	40	-4	10	10	-7	0
RT	31	24	-2	9	9	-9	1	17	57	-2	9	9	-9	0
TUE	-29	38	-7	9	9	-12	0	-7	-2	-6	9	9	-13	0
BL	-17	13	0	-14	-14	1	-1	-8	-2	0	-14	-14	0	-1
ULsk	54	35	-3	19	19	-14	0	29	9	-3	19	19	-15	0
UL	54	35	-3	19	19	-14	0	29	9	-3	19	19	-15	0
BC	54	27	-4	26	26	-20	0	39	12	-4	26	26	-20	0
FN	36	20	-8	12	12	-2	0	15	-1	-7	13	13	-2	0
RV	16	9	15	1	1	-9	0	12	3	15	2	2	-10	0
SIG	-43	28	-1	4	4	-13	0	-76	-5	-1	4	4	-13	0

%UAA: Percentage share of utilized agricultural area. pp: percentage points. NA-2: Crop rotation with four crop groups. NB-1: Cattle density is between 0.3 and 2.0 LU per hectares. NB-2: Cattle density is between 0.3 and 1.4 LU per hectares. NC-4: Regional typical pasture. NE-2: Greening of arable area in autumn. NE-3: Greening of set-aside area.

Table 5.1-30: Development of crop production area in NUTS3 regions in the scenario EXT (results from Section 3.6).

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
S	-11	7	0	0	-15	3	0	-4	5	-1	0	0	0	0	0	0	-6	0	2	-44	0	0	0	-2	0	7	-5	0
BB	-42	0	0	2	9	7	0	0	5	1	0	0	0	0	3	1	-2	1	3	-53	0	0	0	-6	1	-3	10	0
ES	-13	-2	0	2	0	0	0	-2	5	0	0	0	0	0	1	0	-4	0	3	-34	0	0	0	0	6	-3	4	0
GP	-18	1	-1	-5	5	1	0	0	4	0	0	0	0	0	-1	0	-2	1	1	-41	0	0	0	0	3	-2	4	0
LB	-27	0	0	1	-14	1	0	-2	11	0	0	0	0	0	0	2	-2	1	3	-51	0	0	0	-4	10	-4	17	0
WN	-22	-1	0	1	-2	5	0	-3	4	0	0	0	0	0	0	0	-2	0	2	-34	0	0	0	-4	3	2	4	0
HNsk	-29	-1	0	1	-3	2	0	-2	7	2	0	0	0	0	1	2	0	1	4	-42	0	0	0	-2	5	-5	12	0
HN	-29	-1	0	1	-3	2	0	-2	7	2	0	0	0	0	1	2	0	1	4	-42	0	0	0	-2	5	-5	12	0
KUEN	-34	-2	0	-3	11	2	0	-3	6	1	0	0	0	0	1	0	-3	0	4	-59	0	0	0	0	10	-2	11	0
SHA	-21	-1	-1	-13	9	5	0	-2	3	2	0	0	0	0	1	0	0	1	2	-57	0	0	0	0	16	-2	13	0
TBB	-39	0	0	6	-7	5	0	0	0	2	0	0	0	0	9	1	-3	0	8	-70	0	0	0	-2	10	-1	13	0
HDH	-49	-1	-1	-4	23	4	0	0	4	1	0	0	0	0	0	0	-1	0	1	-56	0	0	0	-6	12	0	19	0
AA	-30	0	0	-2	-1	6	0	0	5	1	0	0	0	0	1	0	0	0	2	-52	0	0	0	-4	14	-3	21	0
BAD	-17	0	-2	0	7	3	0	-23	3	2	0	0	0	0	0	1	-2	0	8	-19	0	0	0	-6	2	-3	10	0
KAsk	-22	0	-3	-1	-16	2	0	-8	9	1	0	0	0	0	1	1	-2	1	7	-49	0	0	0	-4	3	-4	10	0
KA	-22	0	-3	-1	-16	2	0	-8	9	1	0	0	0	0	1	1	-2	1	7	-49	0	0	0	-4	3	-4	10	0
RA	-17	0	-2	0	7	3	0	-23	3	2	0	0	0	0	0	1	-2	0	8	-19	0	0	0	-6	2	-3	10	0
HDsk	-20	0	0	0	-18	2	0	-6	9	0	0	0	0	0	1	1	0	0	6	-47	0	0	0	-2	9	-4	12	0
MAsk	-20	0	0	0	-18	2	0	-6	9	0	0	0	0	0	1	1	0	0	6	-47	0	0	0	-2	9	-4	12	0
MOS	-43	0	0	5	-3	4	0	-1	9	1	0	0	0	0	5	0	-3	0	7	-72	0	0	0	0	13	-2	12	0
HD	-20	0	0	0	-18	2	0	-6	9	0	0	0	0	0	1	1	0	0	6	-47	0	0	0	-2	9	-4	12	0
PFsk	-24	0	0	-2	-2	6	0	-2	18	0	0	0	0	0	1	0	-10	1	4	-47	0	0	0	-6	6	6	5	0
CW	-18	0	-1	-1	-5	6	0	0	2	0	0	0	0	0	1	0	-1	1	4	-40	0	0	0	-4	7	1	-3	0
PF	-24	0	0	-2	-2	6	0	-2	18	0	0	0	0	0	1	0	-10	1	4	-47	0	0	0	-6	6	6	5	0

	Winter wheat	Spring wheat	Rye	Winter barley	Spring barley	Oats	Triticale	Grain maize	Energy maize	Fodder peas	Late potatoes	Early potatoes	Sugar beet	Vegetables	Winter rapeseed	Sunflower seed	Silage maize	Apples	Vine	Set-aside	Grassland	Hop	Conv. of grassland[q]	Conv. of arable land[r]	Intensive Grassland	Extensive Grassland	Grassland used	Grassland abandoned
	pp	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**	**pp**
FDS	-23	-2	-1	-1	-7	6	0	0	0	1	0	0	0	0	6	0	-1	0	4	-47	0	0	0	-1	0	1	-2	0
FRsk	-6	0	0	0	-1	1	0	-15	1	1	0	0	0	0	0	1	0	0	3	-12	0	0	0	-10	7	13	4	0
FR	-6	0	0	0	-1	1	0	-15	1	1	0	0	0	0	0	1	0	0	3	-12	0	0	0	-10	7	13	4	0
EM	-6	2	1	1	1	2	0	-23	0	0	0	0	0	0	0	0	0	-2	4	-4	0	0	0	-8	6	-5	19	0
OG	-12	1	1	2	6	3	0	-20	0	0	0	0	0	0	0	1	0	0	5	-6	0	0	0	-8	2	-6	17	0
RW	-32	-1	0	-5	17	6	0	0	1	0	0	0	0	0	7	0	-2	0	1	-44	0	0	0	1	-6	1	-12	0
VS	-5	0	0	3	-1	4	0	0	1	2	0	0	0	0	7	0	-2	0	3	-19	0	0	0	0	-8	-5	-3	0
TUT	-8	0	0	4	-3	4	0	0	1	0	0	0	0	0	5	0	-3	1	4	-24	0	0	0	0	-12	1	-12	0
KN	-26	0	0	1	-7	2	0	-2	10	0	0	0	0	0	4	0	-3	1	4	-49	0	0	0	-2	1	-3	6	0
LOE	-7	1	0	2	1	1	0	-8	0	0	0	0	0	0	0	0	-3	0	2	-10	0	0	0	-2	9	3	6	0
WT	-13	-1	0	1	-3	4	0	0	3	0	0	0	0	0	0	0	-1	0	2	-27	0	0	0	0	6	-2	7	0
RT	-19	0	0	2	-6	5	0	0	1	2	0	0	0	0	3	0	-5	-3	4	-37	0	0	0	-6	8	-2	10	0
TUE	-10	-1	0	-4	-1	-1	0	-2	11	2	0	0	0	0	-1	-1	-2	1	5	-55	0	0	0	0	-7	-1	-7	0
BL	-1	0	0	1	-1	7	0	0	1	0	0	0	0	0	4	0	-1	1	2	-17	0	0	0	0	-29	0	-29	0
ULsk	-34	0	1	6	-7	7	0	-1	4	1	0	0	0	0	4	0	-3	0	2	-67	0	0	0	-4	13	-2	20	0
UL	-34	0	1	6	-7	7	0	-1	4	1	0	0	0	0	4	0	-3	0	2	-67	0	0	0	-4	13	-2	20	0
BC	-40	0	0	-3	5	5	0	-1	13	0	0	0	0	0	2	0	-4	-3	2	-64	0	0	0	-4	20	3	21	0
FN	-10	0	0	0	-1	0	0	-9	6	0	0	0	0	0	0	2	-3	0	2	-21	0	0	0	-6	1	-6	13	0
RV	-8	-1	0	-5	2	0	0	-2	4	0	0	0	0	0	0	0	-1	-2	1	-19	0	0	0	-2	11	8	4	0
SIG	-25	-1	0	3	-4	5	0	0	3	1	0	0	0	0	3	0	-6	0	3	-55	0	0	0	-2	1	0	3	0

pp: percentage points.